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Francis Bacon

*and the Transformation of
Early-Modern Philosophy*

Stephen Gaukroger



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Francis Bacon and the Transformation of Early-Modern Philosophy

This ambitious and important book provides the first truly general account of Francis Bacon as a philosopher. It describes how Bacon transformed the values that had underpinned philosophical culture since antiquity by rejecting the traditional idea of a philosopher as someone engaged in contemplation of the cosmos.

The book explores in detail how and why Bacon attempted to transform the largely esoteric discipline of natural philosophy into a public practice through a program in which practical science provided a model that inspired many from the seventeenth to the twentieth centuries. Stephen Gaukroger shows that we shall not understand Bacon unless we understand that a key component of his program for the reform of natural philosophy was the creation of a new philosophical persona: a natural philosopher shaped through submission to the dictates of Baconian method. Thus, we begin to glimpse how the scientific paradigm for cognitive inquiry in our own culture was formed.

This book will be recognised as a major contribution to Baconian scholarship of special interest to historians of early-modern philosophy, science, and ideas.

Author of several important books including an intellectual biography of Descartes (1995), Stephen Gaukroger is Professor of History of Philosophy and History of Science at the University of Sydney.

Francis Bacon

and the Transformation of Early-Modern Philosophy

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CAMBRIDGE
UNIVERSITY PRESS

PUBLISHED BY THE PRESS SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE
The Pitt Building, Trumpington Street, Cambridge, United Kingdom

CAMBRIDGE UNIVERSITY PRESS

The Edinburgh Building, Cambridge CB2 2RU, UK
40 West 20th Street, New York, NY 10011-4211, USA
477 Williamstown Road, Port Melbourne, VIC 3207, Australia
Ruiz de Alarcón 13, 28014 Madrid, Spain
Dock House, The Waterfront, Cape Town 8001, South Africa

<http://www.cambridge.org>

© Cambridge University Press 2004

First published in printed format 2001

ISBN 0-511-03234-X eBook (Adobe Reader)

ISBN 0-521-80154-0 hardback

ISBN 0-521-80536-8 paperback

*For
Helen, Cressida, and Hugh*

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Acknowledgments

I have built up some debts in the course of writing this book. In spite of the fact that the Australian tertiary system is, like many other university systems in the Anglophone world, in a state of contraction and crisis, and in spite of a parochiality prevalent in Anglophone philosophy which constrains many of its practitioners to see present problems as the only guide to what is of value in the past, work on the book has been undertaken under near ideal conditions. In particular, the Australian Research Council has funded regular relief from teaching, as well as visits to European libraries. I have presented material from the book at conferences or seminars in Auckland, Berlin, Canberra, Hong Kong, Liège, Rio de Janeiro, Rome, and Sydney over the past five years, and I am grateful to participants at these sessions for some probing questions. I am particularly indebted to Conal Condren for enthusiastically pointing out to me what was right with an earlier draft of the book, to Mordechai Feingold for diplomatically pointing out what was wrong with it, and to two erudite anonymous referees. I am also grateful for conversations and correspondence with many people who have helped the book along, especially Peter Anstey, Constance Blackwell, Emily Booth, Floris Cohen, Beatriz Domingues, Marta Fattori, Peter Harrison, Rod Home, Ian Hunter, Helen Irving, Timo Kaitaro, Jamie Kassler, Julian Martin, Guillermo Ranea, Graham Rees, Tim Reiss, John Schuster, Michael Shortland, and John Sutton.

References to Bacon's works

The *The Works of Francis Bacon* appeared between 1857 and 1861, edited by James Spedding, Robert Leslie Ellis, and Douglas Denon Heath, in seven volumes, and the *Letters and Life of Francis Bacon* (also called the *Works*, vols. 8–14) appeared between 1861 and 1874, edited by James Spedding, also in seven volumes. These London editions – not to be confused with the American edition of Spedding, which omits the *Life and Letters* but which nevertheless takes up fifteen volumes – are now available complete in a fourteen-volume facsimile reprint (Stuttgart/Bad Cannstatt, 1989), in which the *Works* proper appear as volumes 1–7 and the *Letters* as volumes 8–14.

I refer to this edition collectively as *Works*, and the volumes consecutively as volumes 1–14. I preface the reference with the title (or abbreviated title) of the work, and then give the location in the fourteen-volume works. For example: *Nov. Org.* II xxiii: *Works* i. 269/iv. 156 refers to *Novum Organum*, Book 2, section 23, original text to be found in volume 1, and English translation in volume 4, of the continuously numbered volumes of the *Works*. Julian dates have been converted into modern chronology, with the years beginning on 1 January.

A few improved texts have been issued since the Spedding edition, and Spedding himself issued an improved version of one text, 'A Conference on Pleasure', in 1870. Also, a few manuscripts have been discovered since the Spedding edition, and this material is to be included in a new complete edition of Bacon's writings to be published by Oxford University Press, which will eventually supersede Spedding. Only volume 6 in this edition has appeared at the time of writing, although this includes the important Hardwick manuscript *De Vijs Mortis*, the most significant piece missing from Spedding. References to this volume are abbreviated as BW vi.

Although I cite English translations where available, I have not always followed Spedding and Ellis's translations of Bacon's Latin, which are occasionally rather laboured and literal; nevertheless, I have kept changes to a minimum. Benjamin Farrington's *The Philosophy of Francis*

Bacon (Chicago, 1964) contains exemplary translations of several pieces not translated in Spedding and Ellis, and I have used Farrington's translations where available. References to that volume are abbreviated as *PFB*.

The following abbreviations of individual works by Bacon have been used:

<i>Aditus</i>	<i>Aditus ad Titulos in Proximus Quinque Menses Destinatos</i> (appendix to <i>Historia Ventorum</i>)
<i>Adv. Learn.</i>	<i>Advancement of Learning</i>
<i>Advertisement</i>	<i>An Advertisement touching the Controversies of the Church of England</i>
<i>Cog. & Vis.</i>	<i>Cogitata et visa de Interpretatione Naturæ, sive de Inventione Rerum & Operum</i>
<i>Cog Nat Rer.</i>	<i>Cogitationes de Natura Rerum</i>
<i>De Aug.</i>	<i>De Dignitate & Augmentis Scientiarum Libri IX</i>
<i>De Interp. Nat.</i>	<i>De Interpretatione Naturæ Prooemium</i>
<i>De Princ.</i>	<i>De Principiis atque Originibus, Secundum Fabulas Cupidinis et Coeli: sive Parmenides & Telesii, & Præcipue Democriti Philosophia, Tractata in Fabula</i>
<i>De Sap. Vet.</i>	<i>De Sapientia Veterum Liber ad Inclytam Academium Cantabrigiensem</i>
<i>De Vijs</i>	<i>De Vijs Mortis, et de Senectute Retardanda, atque Instaurandis Viribus</i>
<i>Dens. & Rar.</i>	<i>Historia Densi et Rari</i>
<i>Distrib. Op.</i>	<i>Distributio Operis</i>
<i>Flux.</i>	<i>De Fluxu et Refluxu Maris</i>
<i>Glob. Intell.</i>	<i>Descriptio Globi Intellectualis</i>
<i>Hist. Vent.</i>	<i>Historia Ventorum</i>
<i>Med. Sac.</i>	<i>Meditationes Sacræ</i>
<i>New Atl.</i>	<i>New Atlantis</i>
<i>Nov. Org.</i>	<i>Novum Organum</i>
<i>Parasceve</i>	<i>Parasceve ad Historiam Naturalem et Experimentalem</i>
<i>Ph. Univ.</i>	<i>Historia Naturalis et Experimentalis ad Condendam Philosophiam: sive Phenomena Universi</i>
<i>Redarg.</i>	<i>Redargutio Philosophiarum</i>
<i>Sylva</i>	<i>Sylva Sylvarum</i>
<i>Th. Cæli</i>	<i>Thema Coeli</i>
<i>Val. Term.</i>	<i>Valerius Terminus of the Interpretation of Nature, with the Annotations of Hermes Stella</i>
<i>Vit. & Mort.</i>	<i>Historiæ Vitæ & Mortis</i>

Prologue

Cicero tells us that Cato had applied himself to philosophy, not that he might dispute like a philosopher, but that he might live like one. Bacon quotes this remark on a number of occasions, and it invokes a conception of philosophy that dominated not just antiquity but also the early-modern era. It is a conception according to which there is a way of engaging intellectual, cultural, moral, scientific, and aesthetic problems which is not only distinctive, marking out the philosophical treatment of these problems from that of the theologian or the statesman or the artist, for example, but whereby the philosopher is someone who has a particular standing, a particular claim to be heard. Rightly or wrongly, the scientist has now largely usurped much of this role from the philosopher – it is now the scientist, rather than the philosopher, who lays claim to a ‘theory of everything’, for example – and although this shift was consolidated only in the nineteenth century, the influence of Bacon has been such that it is to him, more than anyone else, that we must trace its origins. For it is Bacon who, more than anyone else, urges and guides the transformation of philosophers into what later came to be known as scientists, inducing the birth of a new discipline quite different from philosophy as traditionally practised, and leaving not just philosophy, but the humanities generally, with the problem of forging a new identity for themselves.

From the time of his death in 1626 onwards, Bacon’s fortunes have risen and fallen dramatically. As Pérez-Ramos has pointed out, the fluctuations in Baconian stocks derive in large part from the kinds of investments that have been made in them.¹ Immediately after his death, a rad-

1 Antonio Pérez-Ramos, *Francis Bacon’s Idea of Science and the Maker’s Knowledge Tradition* (Oxford, 1988), chap. 2, which serves as the best general account of these questions. See also Theodore M. Brown, ‘The Rise of Baconianism in Seventeenth-Century England: A Perspective on Science and Society during the Scientific Revolution’, in *Science and History: Studies in Honor of Edward Rosen*, *Studia Copernica* 16 (Wrocław, 1978), 501–22.

ical 'Puritan' interpretation was placed on his work, which located it firmly within a millenarian framework and emphasised the idea of the mechanical arts as a means of moral self-perfection.² By 1660, however, Baconianism was the foundation for the apologetics of the Royal Society, which saw itself as the only heir to Bacon, a view institutionalised in Sprat's *History of the Royal Society of London*, which appeared in 1667.³ This view was reinforced by a wholesale association of Baconianism and Newtonianism. In spite of the fact that Newton, who owned a significant number of books, probably possessed neither of Bacon's two key 'methodological' works – *Novum Organum* and *De Dignitate & Augmentis Scientiarum*⁴ – Bacon was widely regarded as having provided Newton with his methodological foundations. This was a reading propounded by Newton's editors – Maclaurin, Cotes, and Pemberton – in the eighteenth century, and at the end of that century Reid could write confidently that 'Lord Bacon first delineated the only solid foundation on which natural philosophy can be built; and Sir Isaac Newton reduced the principles laid down by Bacon into three or four axioms which he calls *regulae philosophandi*.'⁵

Bacon's success in Europe in the latter part of the seventeenth century was spectacular. In the Netherlands, which was the principal source of Latin editions of Bacon, there were forty-five printings/editions of his

2 This episode in the history of Baconianism is pursued in detail in Charles Webster, *The Great Instauration: Science, Medicine and Reform (1626–1660)* (London, 1975). See also Stephen Clucas, 'In Search of "The True Logicke": Methodological Eclecticism among the "Baconian Reformers"', in Mark Greengrass, Michael Leslie, and Timothy Raylor, eds., *Samuel Hartlib and Universal Reformation* (Cambridge, 1994), 51–74.

3 Different as the Puritan and Royal Society conceptions of Baconianism are, it is worth noting that John Wallis records that the suggestion of regular scientific meetings which were to form of basis of the Royal Society first came from the Puritan Theodore Haak in 1645, although neither Sprat in his *The History of the Royal-Society of London for the Improving of Natural Knowledge* (London, 1667), nor Wallis himself in his *A Defence of the Royal Society in Answer to the Cavails of Doctor William Holder* (London, 1678), make any mention of Haak. See Webster, *Great Instauration*, 54–6. On the beginnings of the Royal Society see Michael Hunter, *The Royal Society and Its Fellows, 1660–1700: The Morphology of an Early Scientific Institution*, 2d ed. (London, 1994).

4 Pérez-Ramos, *Francis Bacon's Idea of Science*, 17 n. 24, notes that Harrison's catalogue of Newton's library lists only the *Essayes*, the *De Sapientia Veterum*, and Rawley's *Opuscula Varia Posthuma*. Harrison's listing is about 90 per cent complete.

5 *The Works of Thomas Reid*, ed. Sir William Hamilton, 2 vols. (London, 1863), i.437b (*Essays on the Intellectual Powers of Man*, essay 6). See the discussion in Larry Laudan, *Science and Hypothesis: Historical Essays on Scientific Methodology* (Dordrecht, 1981), chap. 7.

works before 1700.⁶ In Italy, there were fourteen printings/editions before 1700,⁷ and following the closing of the Accademia del Cimento in 1667, a new academy, the Accademia della Traccia ('academy of traces/footprints/tracks') was founded along explicitly Baconian lines, as 'tracking down the true understanding of nature along the . . . road of experience.'⁸ In France, England's great competitor for the mantle of patron of the sciences, where there were thirty-three printings/editions of Bacon before 1700,⁹ the Académie Royale des Sciences, founded in 1666, was created by Colbert, chief minister to Louis XIV, in what Colbert referred to as 'the manner suggested by Verulam'.¹⁰ Voltaire devotes the twelfth of his *Lettres philosophiques* to the praise of Bacon, and his impact on the French Enlightenment was considerable.¹¹ Indeed, Baconianism was so deeply implicated in the Enlightenment advocacy of science that with the Romantic reaction to it Bacon was singled out as a prime culprit: William Blake claimed that it was Bacon who had ruined England, while De Maistre was blaming the French Revolution on Bacon.¹² And it is certainly true that in the late-eighteenth-century French debate over 'republican' versus 'monarchical' science, Baconianism was employed by supporters of the former, principally in the advocacy of natural history as a nonelitist form of science.¹³

6 See the list of editions in R. W. Gibson, *Francis Bacon: A Bibliography of His Works and of Baconiana, to the Year 1750* (Oxford, 1950). Most of the editions produced in the Netherlands were Latin editions, as Leiden and Amsterdam were centres of Latin publishing.

7 Ibid.

8 See Marta Cavazza, 'Bologna and the Royal Society of the Seventeenth Century', *Notes and Records of the Royal Society of London* 35 (1950), 105–23, at 107.

9 Gibson, *Francis Bacon: A Bibliography*.

10 See letter of 1666 from Huygens to Colbert in Huygens, *Oeuvres complètes de Christiaan Huygens*, ed. La Société Hollandaise des Sciences, 22 vols. (The Hague, 1888–1950), vi.95–6. The Académie, which received funds from the king, was comprised largely of professional researchers. The Royal Society, on the other hand, relied on private funding, and two-thirds of its membership was made up of the nobility (honorary members) and amateurs who were able to top up funding. See Henry Lyons, *The Royal Society, 1660–1940* (New York, 1968), 76–7.

11 Diderot's 'Introduction' to the *Encyclopédie* makes Bacon's influence clear. On this question more generally, see M. Malherbe, 'Bacon, l'*Encyclopédie* et la Révolution', *Études philosophiques* 3 (1985): 387–404.

12 Pérez-Ramos, *Francis Bacon's Idea of Science*, 20. Not all Romantics derided science, of course, and Coleridge remarked that Bacon was 'the founder of a revolution scarcely less important for the scientific . . . world than that of Luther for the world of religion and politics': cited in Perez Zagorin, *Francis Bacon* (Princeton, 1998), 32.

13 See William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, 1994), 349.

A similar phenomenon took place in American thought, and the American Constitution drew on Bacon's advocacy of induction, with Jefferson commissioning portraits of the three 'great minds' – Bacon, Newton, and Locke – for his office in the State Department. Bacon was considered of particular significance because the lessons of experience were more important for the New World than they had ever been for Europeans: There was something especially appropriate about Bacon's outlook for the colonisers of the New World.¹⁴ By the nineteenth century, however, we find a very significant change of focus. During the revival of interest in Bacon in England in that century, in writers such as the astronomer John Herschel, the historian of science William Whewell, and the philosopher John Stuart Mill, Baconianism comes to be stripped of any political connotations, and methodological-cum-epistemological questions now dominated the discussion,¹⁵ a domination that continued at least until the middle of the twentieth century.¹⁶

These changes to what has been seen as relevant in Bacon's work in many ways mirror developments in the discipline of philosophy itself. Such changes in the discipline have often been thought about purely in terms of variations in the content of philosophical doctrines – this is what histories of philosophy almost always confine themselves to, for example – even though there is some awareness that more than just content changes between the late-mediaeval and Renaissance philosophers and the pioneers of early modern philosophy such as Descartes, Hobbes, and Gassendi. There has been a change in mentality, a change in the un-

14 See I. Bernard Cohen, *Science and the Founding Fathers* (New York, 1995), 56–9.

15 There is an exemplary nineteenth-century discussion of Bacon in chap. 11 of Book 12 of William Whewell's *The Philosophy of the Inductive Sciences*, rev. ed., 2 vols. (London, 1847), ii.226–51.

16 Nothing brings out more graphically the fact that Bacon was taken to be representative not just of seventeenth-century thought, but of modern thought more generally, than his reception in China. When Western philosophy was reintroduced into China in the nineteenth century (having first been introduced briefly, along with Western science and theology, two centuries earlier by Jesuit missionaries, before their expulsion), it was Bacon who was taken as representative of Western thought, as being a key English thinker, along with Darwin and Spencer. The article on Bacon published in 1873 by Wang Tao, who collaborated with the missionary James Legge in his translations of classical Chinese philosophical texts, was the first article in Chinese devoted to a Western philosopher, and Wang followed it up in 1877 with a translation of Bacon's *Novum Organum*. Indeed, Bacon's work was widely read and discussed in the 1890s and early decades of the twentieth century in China, and it formed virtually a sole point of entry into the modern Western philosophical tradition. For details, see Yuan Weishi, 'A Few Problems Related to Nineteenth Century Chinese and Western Philosophies and Their Cultural Interaction', *Journal of Chinese Philosophy* 22 (1995), 153–92, esp. 164–5, 174–5.

derstanding of the point of the exercise, a change in what the rationale of pursuing philosophy was. What emerged in the West in the early-modern era was a style of doing natural philosophy, a way of thinking about the place of natural philosophy in culture generally, and of thinking about oneself as a natural philosopher. This phenomenon is wider than Bacon, and the transformation is one that lasts into the nineteenth century, when the modern notion of a 'scientist' was born.¹⁷ But Bacon's was the first systematic, comprehensive attempt to transform the early-modern philosopher from someone whose primary concern is with how to live morally into someone whose primary concern is with the understanding of and reshaping of natural processes. And his was the first systematic, comprehensive attempt to transform the epistemological activity of the philosopher from something essentially individual to something essentially communal.

17 Andrew Cunningham and Perry Williams, 'De-centering the "Big Picture": The Origins of Modern Science and the Modern Origins of Science', *British Journal for the History of Science* 26 (1993), 407–32.

The nature of Bacon's project

From arcane learning to public knowledge

Bacon's project was to harness firmly to the yoke of the state a new attitude to knowledge, and in the course of attempting to do this, he was led to think through and transform this new attitude to knowledge. At the most elementary level, his aim was to reform natural philosophy, but what exactly he was reforming, and how he envisaged its reform, are not straightforward questions. The object of this reform was both the practice and the practitioners of natural philosophy. He was concerned to reform a tradition of natural philosophy in which the central ingredients were areas such as natural history and alchemy: empirical, labour-intensive disciplines.

In a pioneering essay, Kuhn attempted to distinguish between what he referred to as the mathematical and the experimental or 'Baconian' traditions.¹ This is a useful first approximation, and it indicates a divergence of research in the seventeenth and eighteenth centuries (although Newton, for example, was considered to have produced models in both traditions, in his *Principia* and his *Opticks*, respectively).² It is only to be expected that this characterisation is of less help in understanding the way in which fields of research were structured at the time Bacon was writing – and of course it is this that we need to understand if we are to comprehend what Bacon's reforms were directed towards – but there is a similar divergence between two broad kinds of discipline. The first is what I shall call 'practical mathematics' (principally geometrical optics, astronomy, statics, hydrostatics, harmonics, as well as some very ele-

1 Thomas S. Kuhn, 'Mathematical versus Experimental Traditions in the Development of Physical Science', in his *The Essential Tension*, 2d ed. (Chicago, 1977), 31–65. Compare Ian Hacking, *The Emergence of Probability* (Cambridge, 1975), who contrasts the 'high' (i.e., mathematical) sciences with the 'low' (i.e., probabilistic) sciences such as medicine and alchemy, which reason probabilistically rather than conclusively.

2 See I. Bernard Cohen, *Franklin and Newton* (Philadelphia, 1956).

mentary kinematics), which had been pursued in irregular bursts of activity – in the Hellenistic Greek diaspora, in mediæval Islam, in twelfth- and thirteenth-century Paris and Oxford – until, starting in Italy and the Netherlands from the mid-sixteenth century onwards, it began to be pursued in a concerted way in Western Europe. Bacon had very little interest in this kind of area. His concerns in natural philosophy were focused on disciplines and activities which make up a second, far more disparate, grouping, the ingredients of which were resolutely practical and relatively piecemeal. Many of them had traditionally been associated with crafts, like metallurgy, where the secrets were jealously protected; or with agriculture where, along with widely shared abilities which those who worked the land picked up as a matter of course, there were closely guarded skills – in viniculture, for example – which were not shared outside the trade; or with the herbal treatment of various maladies, where esoteric knowledge played a very significant role; or with alchemy, where the arcane nature of the knowledge was virtually a *sine qua non* of the discipline.³ William Eamon has recently drawn attention to the shift from esoteric to public knowledge, a shift he traces primarily to the sixteenth and seventeenth centuries, and has shown how it played an important role in the transformation of scientific culture in this period.⁴ There can be little doubt that this is a crucial element in Bacon's reform. As he puts it in the *Advancement of Learning*,

The sciences themselves which have had better intelligence and confederacy with the imagination of man than with his reason, are three in number; Astrology, Natural Magic, and Alchemy; of which sciences nevertheless the ends are noble. For astrology pretendeth to discover that correspondence or concatenation which is between the superior globe and the inferior; natural magic pretendeth to call and reduce natural philosophy from variety of speculations to the magnitude of works; and alchemy pretendeth to make separation of all the unlike parts of bodies which in mixtures of nature are incorporate. But the derivations and prosecutions to these ends, both in the theories and in the practices, are full of error and vanity; which the great professors themselves have sought to veil over and conceal by enigmatical writings, and referring themselves to auricular traditions, and such other devices to save the credit of impostures. (*Adv. Learn.* I: Works iii.289)⁵

3 A good example of the esoteric nature of alchemy is to be found in George Starkey – aka Eireneus Philalethes ('a peaceful lover of truth') – one of the most important seventeenth-century alchemists: See the discussion of Starkey and this question in William R. Newman, *Gehennical Fire: The Lives of George Starkey, an American Alchemist in the Scientific Revolution* (Cambridge, Mass., 1994), chap. 4.

4 William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, 1994).

5 As the alchemical adept Abraham Andrewes put it at the beginning of 'The Hunting of the Greene Lyon': 'All haile to the noble Companie / Of true Students in

Yet deep questions are raised by this issue of the transformation of previously esoteric disciplines into public knowledge. There is some case to be made that the esoteric nature of knowledge in the Middle Ages played a crucial positive role in its development. Comparing the situation in the mediæval West with roughly contemporary societies having strong scientific cultures – the Islamic Middle East and China – Toby Huff, pursuing what might broadly be termed a Weberian approach to these questions, has argued that the formation of autonomous corporate bodies, in the wake of the Investiture Controversy (1050–1122), created a decentralisation of responsibilities and expertise which fostered a protected climate, a neutral space for inquiry, in which intellectual innovation could flourish.⁶ What happened as a result of the Investiture Controversy was that the church was effectively formed as a corporation, declaring itself legally autonomous from the secular order and claiming for itself all spiritual authority. Other corporate bodies were soon formed on this model – towns, cities, guilds, universities, professional groups – and the introduction of corporate structure in the last two cases, in particular, meant that the context in which natural philosophy was pursued was very different from that in the Islamic world and China. Mediæval Islamic thought was very much a development of classical and Hellenistic work in the area of ‘practical mathematics’, but individual successes in optics and astronomy could not be followed up properly because of the very localised and isolated level on which this research was pursued. In China, on the other hand, a totalising bureaucratic structure ruled out opportunities for innovation which were not part of some state-sanctioned programme. Moreover, the model for corporate structure brought with it an elaborate legal structure which harmonised legal traditions and provided a foundation for law, in addition producing a new science of law which became a model of intellectual achievement. Crucial to this cultural dominance of law was a staunchly adversarial mode of reasoning, absent in Chinese legal argument and in its relatively internally undifferentiated pursuit of natural knowledge.⁷

Note 5 (cont.)

holy *Alchimie*, / Whose noble practice doth hem teach / to vaile their secrets wyth mistie speech’. The poem is given, along with many like it, in Elias Ashmole, *Theatrum Chemicum Britannicum. Containing Severall Poeticall Pieces of our Famous English Philosophers, who have written the Hermetique Mysteries in their owne Ancient Language* (London, 1652), 278.

6 Toby Huff, *The Rise of Early Modern Science: Islam, China, and the West* (Cambridge, 1993).

7 For a critical and far more nuanced evaluation of the contrast between the Greek adversarial or agonistic approach and the Chinese irenic or ‘authority-bound’ approach, see G. E. R. Lloyd, *Adversaries and Authorities: Investigations into Ancient Greek and Chinese Science* (Cambridge, 1996), chap. 2.

So, in sum, what we have is a culture of self-governing autonomous corporate bodies which strictly regulated entry to their ranks and protected the privileges associated with membership. Exclusivity is crucial to such bodies, and Bacon is criticising the exclusivity both of the guilds, where practical information is esoteric by virtue of keeping knowledge or techniques within a trade or profession to which access is then restricted, and of the universities, where an esoteric and often convoluted language renders information inaccessible to all but those accepted into the university system. In the case of the universities, Bacon, in common with some of his reform-minded contemporaries, associates its convoluted systems with its adversarial approach, whose aim is to win arguments rather than produce new knowledge, and he rejects both.

Having suggested, however, that Bacon's project for the reform of natural philosophy is at least in part motivated by a desire to shift from esoteric to public knowledge, a word of qualification is necessary. Bacon did not envisage such reforms, if successful, resulting in universal access to knowledge. Quite the contrary, he explicitly argues against such universal access; rather, he sees such knowledge as being something which might serve the monarch, in some ways on a par with territorial conquest:

And this proficience in navigation and discoveries may plant also an expectation of the further proficience and augmentation of all sciences; because it may seem they are ordained by God to be coevalls, that is, to meet in one age. For so the prophet Daniel speaking of the latter times foretelleth ['many pass to and fro, and knowledge shall be multiplied'], as if the openness and through passage of the world and the increase of knowledge were appointed to be in the same ages. (*Adv. Learn.* II: *Works* iii.340)⁸

The association of the conquest of land with the conquest of knowledge is something strikingly depicted in the frontispiece to his *Instauratio Magna* of 1620, where a warship is shown sailing back through the Pillars of Hercules, a traditional symbol of the limits of knowledge but also an emblem the Spanish kings had commandeered to represent their empire.⁹ Bacon explicitly wants to limit access to such knowledge to the

8 The image is also to be found earlier in *Val. Term.* (*Works* iii.220–1), and later in *De Aug.* (*Works* i.514/iv.311–12) and *Nov. Org.* I, Aph. 93 (*Works* i.200/iv.92). On the widespread millenarian reading of the passage from Daniel in the first half of the seventeenth century, see Charles Webster, *The Great Instauration: Science, Medicine and Reform (1626–1660)* (London, 1975), chap. 1.

9 The analogy between territorial conquest and scientific conquest in the science of this period is explored in Timothy Reiss, *The Discourse of Modernism* (Ithaca, 1982), and more recently in Amir Alexander, 'The Imperialist Space of Elizabethan Mathematics', *Studies in History and Philosophy of Science* 26 (1995): 559–92.

monarch: It is to serve national purposes rather than those of some local grouping. In order to do this, however, the information must be acquired and presented in a new way, and correspondingly he wants those who pursue natural philosophy to be very different from traditional practitioners.

A via media

A crucial ingredient in the reform of natural philosophy for Bacon is a reform of its practitioners: If we neglect this element in his programme, we will fail to see what was its practical cutting edge.¹⁰ In this respect, his concerns can be seen as part of a general concern with the reform of behaviour which began outside scientific culture but which was rapidly internalised in English natural philosophy in the seventeenth century.¹¹ A particular way of pursuing natural philosophy was associated with what can only be called a particular form of civility. The investigation of natural processes – observation and experimentation – was contrasted with and pitted against verbal dispute, the first being construed as a procedure by which we actually learn something, the second as consisting of mere unproductive argumentation for its own sake. In a famous passage in the *Advancement of Learning*, Bacon chastises Aristotle on these grounds in strong terms:

And herein I cannot a little marvel at the philosopher Aristotle, that did proceed in such a spirit of difference and contradiction toward all antiquity; undertaking not only to frame new words of science at pleasure, but to confound and extinguish all ancient wisdom; inasmuch as he never nameth or mentioneth an ancient author or opinion, but to confute and reprove. (*Adv. Learn.* II: *Works* iii.352)

And later in the same work he tells us:

I like better that entry of truth which cometh peaceably with chalk to mark up those minds which are capable to lodge and harbour it, than that which cometh with pugnacity and contention. (*Works* iii.363)

In the context of English thought in the early-modern era, the advocacy of experiment over Scholastic disputation, and the advocacy of a 'civil'

10 Two recent accounts of Bacon's reforms have drawn attention to this aspect of his programme: Julian Martin, *Francis Bacon, the State, and the Reform of Natural Philosophy* (Cambridge, 1992), and John E. Leary, Jr., *Francis Bacon and the Politics of Science* (Ames, Iowa, 1994).

11 The phenomenon was not confined to England. For an overview of the situation in England and continental Europe, see Lorraine Daston, 'Baconian Facts, Academic Civility, and the Prehistory of Objectivity', in Alan Megill, ed., *Rethinking Objectivity* (Durham, N.C., 1994), 37–63.

approach in which some form of compromise is sought in scientific and philosophical matters, are indissolubly linked.¹² One crucial thing at stake in both is a rejection of Scholastic disputation: It is both the wrong way for natural philosophy to be pursued and the wrong way for natural philosophers to behave. The key idea is that civility and good sense dictate that one should pursue a *via media*, some form of middle position which both parties to a dispute could accept.¹³

Boyle is perhaps the best example of this linking of the appropriate form of natural-philosophical practice with the behaviour appropriate to the natural philosopher. There is a constant attempt in Boyle to find a *via media* in metaphysical disputes. The corpuscular hypothesis, he tells us, is something that transcends metaphysical disputes between the Cartesian and Epicurean schools, whose hypotheses 'might by a person of a reconciling disposition be looked on as . . . one philosophy.'¹⁴ Eclecticism is presented here as an ingredient in gentlemanly behaviour, something to be contrasted with the adversarial mode of Scholastic disputation. Boyle is possibly developing a theme in Bacon, for Bacon himself explicitly defends the *via media*, telling us in *Temporis Partus Masculus* that Democritus 'destroyed two falsehoods by knocking their heads together and opened up a middle path to truth.'¹⁵ In the *De Sapientia Veterum*, he uses the images of steering between Scylla and Charybdis, and of the flight of Icarus: 'Moderation or the Middle Way is in Morals much commended, in Intellectuals less spoken of, though not less useful and good.'¹⁶ And, as we shall see, Bacon's theory of 'method', as well as being designed to increase human collective power to discover natural laws and manipulate natural processes, was also intended, as a means to achieving this power, to provide a strict regimen which continually

12 See the discussion of the 'gentlemanly' mode of argument in Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth Century England* (Chicago, 1994), and Steven Shapin and Simon Schaffer, *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, 1985).

13 The notion of a *via media*, which Aristotle had employed in an ethical context, also played an important role in political theory – e.g., in chap. 23 of Niccolò Machiavelli's *The Prince* (trans. George Bull [London, 1970]) – and it is quite likely that both these areas served as models in some respects, although I have been unable to trace out exact correspondences.

14 Preface to *Some Specimens of An Attempt to make Chymical Experiments useful to illustrate the notions of the Corpuscular Philosophy*, in *The Works of the Honourable Robert Boyle*, ed. T. Birch, 2d ed., 6 vols. (London, 1772), i.355–8; quotation from p. 356.

15 *Works* iii.537; Benjamin Farrington, *The Philosophy of Francis Bacon: An Essay on Its Development from 1603 to 1609 with New Translations of Fundamental Texts* (Chicago, 1964), 71.

16 *Works* vi.754.

curbed the spontaneous tendencies of the mind. This can be done because of the manipulability of the human mind:

But certain it is . . . that as the most excellent of metals, gold, is of all other the most pliant and most enduring to be wrought; so of all living and breathing substances, the perfectest (Man) is the most susceptible of help, improvement, impression, and alteration. And not only in his body, but in his mind and spirit. And there again not only in his appetite and affection, but in his power of wit and reason. (*Works* vii.99)

Later, comparing the lame man who, because he takes the right road, outstrips the swift runner who has taken a wrong road, and whose very swiftness leads him further and further from his goal, Bacon explains that his way of discovery in science 'leaves but little to the acuteness and strength of wits, but places all wits and understanding nearly on a level',¹⁷ repeating the point later in *Novum Organum*:

For my way of discovering sciences goes far to level men's wits, and leaves but little to individual excellence; because it performs everything by the surer rules and demonstrations. (*Nov. Org.* I cxxii: *Works* i.217/iii.109)

Bacon's is a theory about how to shape scientists (as they will subsequently come to be known), so that, contrary to their natural inclinations, they manifest the requisite good sense and behaviour in their observation and experiment. Avoiding extremes is important here – to avoid the 'Idols of the Cave', for example, we must steer a middle course between 'extreme admirations for antiquity' and 'extreme love and appetite for novelty'¹⁸ – and it is indicative of the fact that Bacon's proposals are as much about reforming behaviour as about following productive procedures.

It may be helpful to think of this reform of behaviour in two ways. In the first place, it is clearly an extension of the emphasis on civility that we find from the late fifteenth century onwards, which is exemplified in the numerous manuals which appeared in the sixteenth century, describing in detail how one should behave – that is, regulate one's behaviour – in a variety of circumstances. In an extremely popular and influential series of manuals that Erasmus published between 1500 and 1530, for example, there are set out rules for how to behave in church, in bed, while at play, while eating, and so on; the manuals are exhaustive, covering everything from dress, deportment, and gestures, to facial expres-

17 *Nov. Org.* I lxi: *Works* i.172/iii.62–3. Compare the claim, in the Preface to the *Instauratio Magna*: *Works* i.129/iv.18, that no degree of 'excellence of wit' can enable us to overcome the obstacles to uncovering the secrets of nature.

18 *Nov. Org.* I lvi: *Works* i.170/iii.59–60.

sions and demeanours.¹⁹ Erasmus's *De Civilitate Morum Puerilium* appeared in English as *A Lytell Booke of Good Maners for Chyldren* in 1532 and spawned a large number of books on these topics: Among them (to confine our attention to the more popular early-seventeenth-century works) were James Cleland's *Hero-Paideia; or, The Instruction of a Young Nobleman* (Oxford, 1607), William Fiston's *The Schoole of Good Manners* (London, 1609), Richard Weste's *The Booke of Demeanour* (London, 1619), Henry Peacham's *The Compleat Gentleman* (London, 1622), and Robert Brathwayt's *The English Gentleman* (London, 1630).²⁰ Bacon's *Essayes* – in their final edition entitled *The Essayes or Counsels, Civill and Morall* – can be seen as making some contribution to this genre, as they deal with various passions and how to control them, and offer advice on various social questions: parenthood, marriage, friendship, custom, education, and so on.²¹

It may also be helpful, however, to compare Bacon's plan to direct scientific activity by inculcating new habits in scientists with the much later reform of medical practice, inaugurated by Joseph Lister in the late 1860s, whereby surgeons and nursing staff were subjected to a new and severe regimen conducive to antiseptic conditions, a regimen which required a complete change in the deportment of surgical and medical staff. Indeed, it is difficult to imagine that the kind of highly regulated regime of cleanliness and alertness to infection that Lister introduced could have been possible unless there was already an ethos of self-examination and responsibility for the self which effectively begins in earnest with the kind of intense moral self-examination that we find in the sixteenth century.²² Subjection to such regimes, which involve a sig-

19 There is a representative selection of these writings in translation in section 2 of *The Erasmus Reader*, ed. Erika Rummel (Toronto, 1990). On the role of civility and etiquette, see Norbert Elias, *State Formation and Civilization* (Oxford, 1982) and his *The Court Society* (Oxford, 1983); and more specifically on civility in England, Sir Ernest Barker, *Traditions of Civility* (Cambridge, 1948).

20 On this genre in England, see Anna Bryson, 'The Rhetoric of Status: Gesture, Demeanour and the Image of the Gentleman in Sixteenth- and Seventeenth-Century England', in Lucy Ghent and Nigel Llewellyn, eds., *Renaissance Bodies: The Human Figure in English Culture, c. 1540–1660* (London, 1990), 136–53. The genre is transformed into a concern with politeness in the eighteenth century: See Lawrence Klein, *Shaftesbury and the Culture of Politeness* (Cambridge, 1994).

21 *Works* vi.371–517.

22 As Jean Delumeau has pointed out, the problem for both Reformation and Counter-Reformation 'was how to persuade hundreds of millions of people to embrace a severe moral and spiritual discipline of the sort which had never actually been demanded of their forebears, and how to make them accept that even the most secret aspects of their daily lives should thenceforth be saturated by a constant preoccupation with things eternal' ('Prescription and Reality', in Edmund Leites, ed.,

nificant degree of self-regulation, requires that one already have certain skills and capacities, that one already have a certain 'mentality' which places a value on these, and Bacon clearly sees part of his task as inculcating the requisite skills and capacities by instilling the requisite mentality.

Practical knowledge

At the heart of this reform is the production of useful knowledge. The practical nature of knowledge is a particularly pressing issue for Bacon – as we shall see, he denies the title 'truth' to anything unless it is 'productive of new works' – so it is important that we understand what is at stake in this question. The concern with practical knowledge and the practical benefits of knowledge was especially marked in sixteenth-century England. Scholastic disputation was rejected in part because it was considered to be of no benefit to anyone, and there was a tendency among the English humanists of the sixteenth century to consider the practical sciences superior to theoretical knowledge.²³ The Tudor humanist and alchemist Thomas Starkey wrote in the 1530s that

the perfection of man standeth not in mere knowledge and learning without application of it to any use or profit of others, but the perfection of man's mind resteth in the use and exercise of all virtues and honesty, and chiefly in . . . the communing of high wisdom to the use of others.²⁴

In writers outside the context of humanism, we can find a rejection of the classical tradition and an emphasis on many of the elements that Bacon will take up: above all, observation and experiment. One area in which this was particularly pronounced is geography, where the limits of classical writings had become very obvious in the voyages of discov-

Note 22 (*cont.*)

Conscience and Casuistry in Early Modern Europe [Cambridge, 1988], 134–58, at 144). Delumeau has looked at this question in detail in his tetralogy: *La Peur en Occident (XIV^e–XVIII^e siècles): Une cité assiégée* (Paris, 1978); *Le Péché et la peur: La Culpabilisation en Occident, XIII^e–XVIII^e siècles* (Paris, 1983); *Rassurer et protéger: Le Sentiment de sécurité dans l'Occident d'autrefois* (Paris, 1989); and *Une Histoire du Paradis: Le Jardin des délices* (Paris, 1992). See also Gerhard Oestreich, *Neostoicism and the Early Modern State* (Cambridge, 1982), especially chap. 11, 'The Structure of the Absolute State', and R. Po-Chia Hsia, *Social Discipline in the Reformation* (London, 1989).

23 See F. Caspari, *Humanism and the Social Order in Tudor England* (Chicago, 1954), on the importance of the practical sciences for sixteenth-century English humanists, and Paolo Rossi, *Francis Bacon: From Magic to Science* (Chicago, 1968), on the importance of this for Bacon.

24 Thomas Starkey, *A Dialogue between Reginald Pole and Thomas Lipset*, ed. K. M. Burton (London, 1948), 26. Cited in Caspari, *Humanism and the Social Order*, 118.

ery of the fifteenth and sixteenth centuries. Of the three discoveries that the Elizabethans lauded – gunpowder, printing, and the magnetic compass needle – it was the last, as Jones has pointed out, that appeared the most significant, 'not only because it was largely responsible for the discoveries that amazed and thrilled the age, but also because its mystery defied explanation and invited attention and study.'²⁵ And it is in the writers on magnetism that we find the strongly held view that the classical authors have little to offer and that one must start afresh. Gilbert is the best-known example of this attitude, but we can also find it in far less learned writers, such as the seaman turned instrument maker Robert Norman, who, in his *The newe Attractiue* (1581), attacks those who seek knowledge from Latin and Greek texts – they are pedants who promise much and perform little – and offers an empirically based, as opposed to a textually based, procedure:

I meane not to vse barely tedious coniectures or imaginations, but briefly as I maie to passe it ouer, foundyng my arguements only vpon experience, reason, and demonstration, whiche are the groundes of Artes.²⁶

This attitude is taken up by other English writers of the period – by Thomas Blundeville, most noted for his writings on horsemanship and horsebreeding, in his *Exercises* on cosmography, astronomy, geography, and the art of navigation (London, 1594), and by William Barlow, in his *The Navigator's Supply* (London, 1597).²⁷ Gilbert, likewise, in 1600, in the Preface to his *De Magnete*, makes it clear that a new start is needed:

It is permitted us to philosophize freely and with the same liberty which the Egyptians, Greeks, and Latins formerly used in publishing their dogmas: whereof very many errors have been handed down in turn to later authors: and in which smatterers still persist, and wander as though in perpetual darkness. To those early forefathers of philosophy, Aristotle, Theophrastus, Ptolemy, Hippocrates, and Galen, let due honour be ever paid: for by them wisdom hath been diffused to posterity; but our age hath detected and brought to light very many facts which they, were they now alive, would gladly have accepted. Wherefore we also have not hesitated to expound in demonstrable hypotheses those things which we have discovered by long experience.²⁸

25 Richard Foster Jones, *Ancients and Moderns: A Study of the Rise of the Scientific Movement in Seventeenth-Century England* (New York, 1982), 13.

26 Quoted in *ibid.*, 14.

27 See the discussion in J. A. Bennett, 'The Challenge of Practical Mathematics', in Stephen Pumfrey, Paolo L. Rossi, and Maurice Slawinski, eds., *Science, Culture and Popular Belief in Renaissance Europe* (Manchester, 1991), 176–90, at 186–9.

28 William Gilbert, *On the Magnet*, trans. Silvanus P. Thompson (New York, 1958), *iii recto. This is admittedly an extreme statement by Gilbert of his position, and his attitude to antiquity is elsewhere a little more ambivalent.

The often eclectic, unsystematic nature of practical knowledge takes on a new significance when this practical knowledge is explicitly valued more highly than theoretical knowledge. The chief desideratum is practical application, rather than consistency or compatibility with first principles, and in these circumstances a lack of consistency is not likely to be treated as a major failing, if it is noticed at all. This is important in the case of Bacon, for he tended to treat the value of philosophy in terms of its ability to contribute to the general welfare. As he puts it in *Novum Organum*, 'the true and lawful goal of the sciences is none other than this: that human life be endowed with new discoveries and powers.'²⁹ This idea, widely accepted in the seventeenth and eighteenth centuries as providing the rationale for natural philosophy, was set out eloquently by Joseph Priestley in 1768:

[A]ll knowledge will be subdivided and extended; and knowledge, as Lord Bacon observes, being power, the human powers will, in fact, be increased; nature, including both its materials, and its laws, will be more at our command; men will make their situation in this world abundantly more easy and comfortable; they will probably prolong their existence in it, and will grow daily more happy, each in himself, and more able (and, I believe, more disposed) to communicate happiness to others.³⁰

What these kinds of concerns bring to light is something that goes beyond the relation between practical and theoretical knowledge: It raises the question of the aims of knowledge per se. There is a temptation here to think in terms of a divide between 'high science', which aims at truth, and 'low science', which aims at usefulness. But the matter is not so straightforward. Discussions of the standing of science in the twentieth century, in particular, especially as far as philosophers are concerned, have tended to subordinate usefulness to truth: It is ultimately in virtue of being true that theories are useful, so what one must seek is truth. It is this kind of conception that lies behind the idea that the core of Bacon's approach lies in his 'method', or in epistemological questions about the adequacy of induction. Now of course there were questions of truth raised in seventeenth-century natural-philosophical thought, and these did occasionally turn on the nature of the truth that natural philosophy was supposed to capture – whether the aim was simply to

29 *Nov. Org.* I, Aph. 81: *Works* i.188/iii.79. Compare *De Interp. Nat.*, where we are told that the dignity of knowledge is maintained by works of usefulness and power: *Works* iii.519.

30 Joseph Priestley, *Essay on Government* (London, 1768), 6. The Baconian theme of the usefulness of knowledge comes into its own in the eighteenth century: See Larry Stewart, *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660–1750* (Cambridge, 1992).

find something compatible with the evidence, for example, or whether it was to discover how things really are. The question whether a Copernican model of the solar system had a physical interpretation which offered a uniquely true account of the motion of the Sun and the planets is perhaps the best-known example of such a dispute; but in the seventeenth century, this was only one of a number of questions about the nature and aims of scientific understanding, and it was not the issue to which one looked for a rationale for scientific practice. To treat it as the predominant issue will inevitably bring confusion. Bacon's claim that knowledge is power, for example, is widely treated as a provocative claim about knowledge, as if it were on a par with claims that knowledge is a grasp of Forms or universals. But it should in fact be read as a claim about power, about something practical and useful, telling us that knowledge plays a hitherto unrecognised role in power. The model is not Plato but Machiavelli.

There is an instructive comparison to be made here between Bacon's approach and the traditional separation of the practical and the theoretical realms that we find, for example, in Thomas Stanley's *History of Philosophy* (1655–62) – the first history of philosophy in English, and widely read in seventeenth-century England – where the work is broken up along the lines of practical and theoretical philosophical concerns:

Now the life of Man being either *practick*, busied in civil affairs of peace and war, or *Contemplative*, retir'd from publick business to speculation and study of wisdom, Divine or Humane, it follows that this personal history will be twofold likewise.³¹

Compare this with Bacon's diametrically opposed view in a letter of advice to James I on the union of Scotland and England in 1603:³²

I do not find it strange . . . that when Heraclitus, he that was surnamed the obscure, had set forth a certain book which is not now extant, many men took it for a discourse of nature, and many others took it for a treatise of policy and matter of estate. For there is a great affinity and consent between the rules of nature, and the true rules of policy: the one being nothing else but an order in the government of the world, and the other an order in the government of an estate. And therefore the education and erudition of the kings of Persia was in a science which was termed by a name then of great reverence, but now degenerate and taken in ill part: for the Persian magic, which was the secret literature of their kings, was an observation of the contempla-

³¹ Thomas Stanley, *The History of Philosophy: containing the Lives, Opinions, Actions and Discourses of the Philosophers of every Sect*, 2nd ed., 3 vols. (London, 1687), vol. i (n.p.; ¶3 of the Preface).

³² 'A Brief Discourse touching the Happy Union of the Kingdoms of England and Scotland', *Works* x.90.

tions of nature and an application thereof to a sense politic; taking the fundamental laws of nature, with the branches and passages of them, as an original and first model, whence to take and describe a copy and imitation for government. (*Works* x.90)

Bacon's aim is to shape political power around political understanding, and he will argue that this political understanding should ultimately take into account broader forms of knowledge, especially scientific knowledge. His point is not to redefine epistemology but to underpin the responsible use of power.

Among the many respects in which Bacon's advocacy of the practical nature of knowledge shapes his understanding of natural philosophy, there are three that are particularly worth noting: the classification of knowledge; the use of mathematics in natural philosophy; and the role of eclecticism.

The classification of knowledge

In Book 2 of the *Advancement of Learning*, a comprehensive attempt is made to classify the whole of learning,³³ and Bacon's classification is different from traditional ones. Classifications of knowledge had been reasonably common since Aristotle. Although Aristotelian writers such as Zabarella had maintained that any ordering of knowledge must be restricted to individual disciplines and could not be based upon principles unifying separate disciplines, there was no shortage of encyclopædic works in the sixteenth and seventeenth centuries attempting just that, and the idea that a comprehensive classification of knowledge might enable one to discover its gaps and make knowledge more readily transmissible gained popularity throughout the sixteenth and seventeenth centuries.³⁴

In the early-modern era these classifications tended to be motivated didactically, even though the principles of organisation underlying them

33 A diary entry reveals that Bacon considered the project of translating the *Advancement* as early as 1608 (*Works* xi.64). By the time he came to realise this project, in 1624, the work had been expanded. The original *Advancement of Learning* had appeared in two books: Book 1 is virtually identical in the two cases, but Book 2 of the *Advancement* is now divided up into eight books, considerably increased in size from the original. Nevertheless, even in the case of the doctrine of Idols, the difference lies mainly in the addition of detail rather than in the development of new material, and neither the division of subject matter nor the sequence in which questions are discussed deviates significantly from that of the *Advancement*. The notes to the Spedding and Ellis edition of the *Advancement* indicate where additions, expansions, and rearrangements of material have been made in *De Augmentis*.

34 See Leroy E. Loemker, *Struggle for Synthesis: The Seventeenth Century Background of Leibniz's Synthesis of Order and Freedom* (Cambridge, Mass., 1972), 32–6.

may have been relatively abstract.³⁵ The proposed reforms of Ramus, for example, brought with them new ways of classifying knowledge which were based on a new understanding of the nature and role of rhetoric and logic, but the classification was shaped largely by didactic concerns. This meant that things that were not part of the curriculum – and especially those that were not part of the seven liberal arts, which had dominated the curriculum during both the Middle Ages and the Renaissance – tended to be excluded. Aristotle had offered a general classification of knowledge that was based on what he considered to be fundamental distinctions in types of knowledge. He had divided knowledge into the theoretical, productive, and prudential arts/sciences, and subdivided the theoretical into those that deal with what is unchanging and independent ('first philosophy'), with what is unchanging but dependent (mathematics), and with what is changing but independent (natural philosophy), and this classification was still widespread in Bacon's time, Bacon himself adhering to some aspects of it. However, there were areas which Aristotle's and didactically motivated classifications either ignored or marginalised, and sixteenth-century writers tried to incorporate these into their classifications. Cardano's *De Subtilitate* (1550) and *De Rerum Varietate* (1557), for example, cover natural philosophy and various secrets of the trades and medicine. Jakob Wecker's *De Secretis* (1582) moves from the metaphysical and natural-philosophical implications of creation to how to counterfeit coins and gems and how to catch fish. Della Porta's *Magia Naturalis* (1558) deals with many categories usually excluded from classifications of knowledge either because they were considered too ephemeral (the art of beautifying women) or because they cover 'marvels' (optical tricks, invisible writing, etc.); but he also dealt with practical questions in metallurgy and optics which, if they had been covered in other classifications, were covered inadequately. Bacon is keen to include both theoretical and practical knowledge in his classification, and it is guided less by didactic considerations than by an attempt to map out all the kinds of knowledge of which the rational mind was capable, and to find out where the realm of learning is in good shape and where it is in need of cultivation.

At the beginning of Book 2 of the *Advancement of Learning*, Bacon makes it clear that the parts of his 'small globe of the intellectual world', whether civil or scientific, religious or mechanical, are inseparably connected. The 'partitions' between parts of knowledge, he tells us, should 'be accepted for lines and veins, than for sections and separations.' All parts of learning must be 'nourished and maintained from the common fountain,' or else the particular sciences will become 'barren, shallow

35 See the discussion in Lisa Jardine, *Francis Bacon: Discovery and the Art of Discourse* (Cambridge, 1974), chap. 1.

and erroneous.³⁶ Yet Bacon conceives the *philosophia prima* that provides the basic unifying principles underlying knowledge in a way very different from Aristotle and the majority of Scholastic metaphysicians. It is not metaphysics conceived as a science of being-qua-being, as it was for Aristotle. Above all, the particular sciences cannot be subsumed under metaphysics as if they were species of a general genus.³⁷ To think of things in this fashion would effectively be to deny the autonomy of natural philosophy, but this autonomy is something that Bacon has to defend; indeed, it is a *sine qua non* of his project, as we shall see. Natural philosophy will be transformed by Bacon into the paradigm of a practical and useful enterprise, and he certainly does not consider metaphysics in this vein. So one very important thing his classification does (a point to which we shall return in Chapter 3) is to free natural philosophy from the constraints that had traditionally been placed upon it, constraints which prevented it from being pursued in the practical vein that Bacon envisages.

Mathematics and practical learning

The usefulness of mathematics was a disputed question in sixteenth- and early-seventeenth-century England. There was no shortage of able mathematicians in the British Isles,³⁸ and there were attempts to intro-

³⁶ *Adv. Learn.* II: *Works* iii.366–7.

³⁷ See the discussion in Robert McRae, *The Problem of the Unity of the Sciences: Bacon to Kant* (Toronto, 1961), 24–31.

³⁸ The greatest of them all, Thomas Harriot, was a profoundly original mathematician, pioneering the development of algebra, and in the realm of practical mathematics he made no less significant advances in geometrical optics and the mathematical theory of navigation. On Harriot's contribution to algebra, see Johannes A. Lohne, 'Dokumente zur Revalidierung von Thomas Harriot als Algebraiker', *Archive for History of Exact Sciences* 3 (1966–7), 185–205, and his 'Thomas Harriot als Mathematiker', *Centaurus* 11 (1965), 19–45. On his work in navigational theory, see Jon V. Pepper, 'Harriot's Calculation of the Meridional Parts as Logarithmic Tangents', *Archive for History of Exact Sciences* 4 (1968), 359–413, and his 'Harriot's Earlier Work on Mathematical Navigation: Theory and Practice', in John W. Shirley, ed., *Thomas Harriot: Renaissance Scientist* (Oxford, 1974), 54–90. Among the other mathematicians, the most outstanding is John Napier, a Scotsman, who seems to have been investigating imaginary roots of equations around 1570, sixty years before Descartes (his investigations appeared as *De Arte Logistica* (ed. Mark Napier [Edinburgh, 1839]), and he issued the first set of logarithms in 1614 (*Mirifici Logarithmorum Canonis Descriptio, ejusque usus* . . . [Edinburgh]). Also worthy of mention are Henry Briggs, the first Savilian professor of geometry at Oxford, who issued a vastly improved set of logarithmic tables in 1617 (*Logarithmorum Chilias Prima* [London]), and William Oughtred, who produced a concise survey of arithmetic and algebra in his *Clavis Mathematicæ* of 1631 (London, 1648).

duce mathematical studies, but there was also extensive resistance to the teaching and improvement of mathematics. Many of the disputes between these camps hinged on the question of the practical usefulness of mathematics.

The reformers were particularly concerned to press its practical uses. Around 1570, two attempts were made to reform the English system of education, with implications for natural philosophy. The first was a project for a University of London, which took up some of the reforms of Sir Nicholas Bacon (Francis's father). The project was set out in Sir Humphrey Gilbert's *Queene Elizabethes Academy*,³⁹ which appeared some time in the mid to late 1560s. Gilbert was one of England's foremost advocates of colonisation, and he was concerned that the education system of the time left students ill-fitted for this task. He proposed a more practically orientated programme involving, among other things, intensive language learning as well as practical mathematical skills in artillery and fortification.⁴⁰ The proposed reforms got nowhere, however.

More radical was John Dee's *Mathematicall Præface* to the first English translation of Euclid's *Elements of Geometry*,⁴¹ in which he proposed a comprehensive overhaul of the natural philosophy of the day. Although what Dee is concerned with is the promotion of arcane knowledge,⁴² his program for reform is clearly motivated by what he perceives

39 Sir Humphrey Gilbert, *Queene Elizabethes Academy*, ed. F. J. Furnivall for the Early English Text Society (London, 1869).

40 Gilbert's work is discussed in Rossi, *Francis Bacon: From Magic to Science*, 6–7, and in Farrington, *Philosophy of Francis Bacon*, 12–13.

41 The most convenient edition is John Dee, *The Mathematicall Præface to the Elements of Geometrie of Euclid of Megara* (1570), with an introduction by Allen G. Debus (New York, 1975). The translation was the work of Henry Billingsley – a merchant and later mayor of London – although Dee made a number of annotations to the translation, and corrected it in some places (*The Elements of the Geometrie* . . . [London, 1570]). Billingsley, like Dee, had been educated at St. John's College, Cambridge, where there was some interest in mathematics in the 1540s and 1550s. His translation was made not from the Greek, but from the Latin version attributed to Campanus. See W. R. Shenton, 'The First English Euclid', *American Mathematical Monthly* 25 (1928), 505–11.

42 The better-known writings, such as the *Propædeumata Aphoristica* (London, 1558) and the *Monas Hieroglyphica* (Antwerp, 1564), were concerned with arcane knowledge, and its arcane nature plays a significant role in its cognitive standing: See Frances Yates, *The Occult Philosophy in the Elizabethan Age* (London, 1979), chap. 8. Generally on Dee, see Nicholas Clulee, *John Dee's Natural Philosophy* (London, 1988); Peter J. French, *John Dee: The World of an Elizabethan Magus* (London, 1972); and William H. Sherman, *John Dee: The Politics of Reading and Writing in the English Renaissance* (Amherst, 1995). The 'Præface' is relatively silent about the question of the arcane knowledge, but, read in the context of his other writings, there can be little doubt that the Neoplatonism he advocates there is part of a package in which the arcane nature of true knowledge is central.

to be its practical benefits. His discussion of the two disciplines of mathematics, arithmetic and geometry, immediately reveals the scale and significance of his project. Arithmetic – which Dee treats with some sophistication, taking us through various techniques in Cossist algebra – is, he tells us, important not only for the merchant, but also for the physician who needs to know the proportions in which medicines are to be mixed, for the military commander who needs to arrange his soldiers in battle in the most effective way and to calculate how much food will be needed for them, and for the judge and legislator, who must apportion sums according to the law,⁴³ and he describes the practical applications of mathematics in areas such as astronomy, music, statics, cosmography, perspective, and hydrography. Having set out the principal uses of mathematics, Dee ends his account by raising the problem of whether an English translation of Euclid would offer a threat to the universities. Telling us how Italian, German, Spanish, and French translations of Euclid have not harmed continental universities, he proceeds to the benefits of a mathematical education for university students:

And surely, the Common and Vulgar Scholer (much more, the Gramarian) before his comming to the *Vniuersitie*, shall (or may) be, now (according to *Plato* his Counsell) sufficiently instructed in *Arithmetike* and *Geometrie*, for the better and easier learning of all manner of *Philosophie*, *Academicall*, or *Peripateticall*. And by that meanes, goe more cherefully, more skilfully, and speedily forward, in his Studies, there to be learned. And, so, in lesse time, profite more, then (otherwise) he should, or could do. Also many good and pregnant English wittes, of young Gentlemen, and of other, who neuer intend to meddle with the profound search and Studie of Philosophie (in the *Vniuersities* to be learned) may neuerthelesse, now, with more ease and libertie, haue good occasion, vertuously to occupie the sharpnesse of their wittes: where, els (perchance) otherwise, they would in fond exercises, spend (or rather leese) their time: neither seruing God: nor furduring the Weale, common or priuate.⁴⁴

And, finally, the practical consequences for the ‘unlatined’ are spelt out:

Besides this, how many a Common Artificer, is there, in these Realmes of England and Ireland, that dealeth with Numbers, Rule, and Compasse: Who, with their owne Skill and experience, already had, will be hable (by these good helpes and informations) to finde out, and deuise, new workes, straunge Engines, and Instrumentes: for sundry purposes in the Common Wealth? or for priuate pleasure? and for the better maintayning of their owne estate?⁴⁵

43 Dee, *Mathematicall Præface*, sig. *iiii^v–ai^v.

44 *Ibid.*, sig. Aiii^r.

45 *Ibid.*

Dee's *Præface* was ignored by his contemporaries and successors alike, however. Whereas his defence of arcane learning, *Monas Hieroglyphica*, was reprinted four times in the hundred years after its first publication, and was the work on which Dee's reputation largely hung, the *Præface* was not reprinted until 1651, and was not even mentioned by natural philosophers such as Bacon and Boyle who, like Dee, were bent on reform.⁴⁶

Just as claims for the reform of mathematics were couched largely in terms of its practical usefulness, its opponents either attacked its practical usefulness or minimised what use it had. In Roger Ascham's *The Scholemaster* (1570), an extremely influential and very widely used practical guide to the day-to-day running of schools, there is explicit hostility, covering mathematics and logic, with stress placed on how 'mathematical

46 The reasons for the complete failure even to acknowledge Dee's programme are difficult to fathom. It is true that Dee's reputation suffered tremendously after the beginning of his association with the alchemist Edward Kelley in 1582, losing his royal patronage in 1583 and having his house at Mortlake, with his magnificent library and three alchemical laboratories, burned by a mob in the same year: See Deborah E. Harkness, *John Dee's Conversations with Angels: Cabala, Alchemy, and the End of Nature* (Cambridge, 2000). But during the 1570s he had had significant support at court, the queen and the privy councillors sponsoring his plan for calendar reform, and his work in areas such as navigation, and his trigonometric theorems for determining stellar parallax – see John Dee, *Parallacticæ Commentationis Praxeosque Nucleus Quidam* (London, 1573) – were well received. Moreover, his programme for reform in the 'Præface' had largely ignored the more contentious numerological aspects of his conception of mathematics, offering something resolutely practical, in an age when the practical value of knowledge was highly valued, as we have seen. The real problem, I believe, was that Dee failed to achieve a linking of practical mathematical skills with a theoretical interest in natural philosophy generally, despite his own efforts and those of his pupil, Thomas Digges: See Thomas Digges, *Alæ seu Scalæ Mathematicæ* (London, 1573), and the discussion in Francis R. Johnson, *Astronomical Thought in Renaissance England: A Study of English Scientific Writings from 1500 to 1645* (Baltimore, 1937), chap. 6. The two continued to be seen very much as different domains. Part of the problem here might have been that, although Dee's project of raising mathematics to the central natural-philosophical discipline had explicitly relied on an advocacy of Platonic and especially Neoplatonist ideas which were directly opposed to the teachings of Aristotle, he had not taken on the Aristotelian doctrine of the role of mathematics. This doctrine, set out in Book E of the *Metaphysics* and elsewhere, whereby mathematics deals only with abstractions and not with real physical things, was the basis for the understanding of mathematics in the universities, and Dee's programme was simply at odds with the common theoretical understanding of mathematics. Until Aristotle's authority in natural philosophy was undermined, Dee's attempt to explore the importance of mathematics in a practical context had no rationale, outside of his Neoplatonically inspired numerology.

heads' are 'unapt to serve the world.'⁴⁷ This advice sat well with not only the sorry state of general mathematical education but the mathematical practice in sixteenth-century England.⁴⁸ Government accounts

47 Roger Ascham, *English Works*, ed. William A. Wright (Cambridge, 1970), 282–8.

48 The backwardness of England in this respect is remarked upon in Ramus, *Proœmium Mathematicum* (Paris, 1567), 55–9. The situation in the rest of Europe with respect to formal education in mathematics was more complicated. German and Italian mathematics were in a relatively healthy state, with some very important texts on arithmetic appearing in the course of the sixteenth century, such as Girolamo Cardano, *Practica Arithmetica Generalis* (Mediolani, 1539); Gemma Frisius, *Arithmeticae Practicae Methodus Facilis* (Antwerp, 1540); Michael Stifel, *Arithmetica Integra* (Nuremberg, 1544); and Niccolò Tartaglia, *La Prima Parte del general trattato di Numeri e Misuri* (Venice, 1556). Yet the Jesuit mathematician and astronomer Christopher Clavius deplored the prejudice against mathematics and the low quality of mathematics instructors, and had recommended the teaching of mathematical subjects in Jesuit colleges in his pamphlet *Modus quo Disciplinæ Mathematicæ in Scholis Societatis Possent Promoveri* (Rome, 1586): See James M. Lattis, *Between Copernicus and Galileo: Christoph Clavius and the Collapse of Ptolemaic Cosmology* (Chicago, 1994), chap. 2, and Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago, 1995), chap. 2, on Clavius's reforms. As a result of his recommendations, and in spite of their denunciation to the Inquisition by Dominicans (see Rivka Feldhay, *Galileo and the Church* [Cambridge, 1995] on the Jesuit–Dominican disputes on this), some instruction in mathematics was given in Jesuit colleges, but only to that minority of students who stayed on at the college after the basic five years of study of classical (principally Latin) literature. In Descartes's college of La Flèche, for example, mathematics was taught in the second of the three senior years, but only as a subsidiary subject, and it is likely that Descartes got his teeth into mathematical problems only in the classes on military architecture and fortification in the army of Maurice of Nassau, in which he served in 1619, and above all in his collaboration with Isaac Beeckman, who had a background in engineering and practical mechanics, at the end of that year. I stress the practical background to Descartes's interest in mathematics because, generally speaking, mathematics – at least of any degree of sophistication – was not taught in universities at this time. Significant exceptions are the Collegio Romano, where Clavius held classes in mathematics from 1597 to 1610, and the Netherlands, where some mathematics and mechanics were taught in the universities at the end of the sixteenth century. On the former, see Lattis, *Between Copernicus and Galileo*, chap. 1; on the latter, see Klaas van Berkel, 'A Note on Rudolphus Snellius and the Early History of Mathematics in Leiden', in C. Hay, ed., *Mathematics from Manuscript to Print, 1300–1600* (Oxford, 1988), 156–61. It was in practical areas such as fortification, ballistics, architecture, calendar reform, hydrostatics, and shipbuilding that the requisite skills were to be picked up: As A. Rupert Hall has pointed out, 'the profession of the architect-engineer embraced the most sophisticated technology existing in the fourteenth, fifteenth, and sixteenth centuries; it was the one technical profession making large demands on organising and planning ability, drawing-office skills, taste, craft knowledge, and mathematical learning.' 'Science, Technology, and

were still kept in Roman numerals in Tudor England,⁴⁹ for example, and the basic English mathematics text from the middle of the sixteenth to the middle of the seventeenth century, Robert Recorde's *Arithmetick; or, The Grounde of Artes* (1540), was extremely elementary, having to begin by defending the use of Arabic numerals.⁵⁰ In the most influential education textbook of all in Tudor England, Sir Thomas Elyot's *The Booke Named The Governour* (1531),⁵¹ there is no explicit hostility to mathematics: It was just completely absent from the curriculum.⁵²

Bacon took a great interest in practical disciplines, but his attitude to mathematics was at one with Elizabethan educationalists.⁵³ He placed some educational store by mathematics, but he conceived the usefulness of pure mathematics exclusively in terms of helping the concentration, and he has little to say on practical or 'mixed' mathematics. In the *Advancement of Learning*, in pointing out the uses of 'pedantical knowledge' for the young, he remarks that 'if a child be bird-witted, that is, hath not the faculty for attention, the Mathematics giveth a remedy thereunto; for in them, if the wit be caught away but one moment, one is new to begin.'⁵⁴ Setting out the province of mathematics in more detail earlier in the same book, the picture offered is straight out of Aristotle:

The Mathematics is either Pure or Applied. To the Pure Mathematics are those sciences belonging which handle Quantity Determinate, merely severed from any axioms of natural philosophy; and these two are, Geometry

Warfare, 1400–1700', in M. D. Wright and L. J. Paszek, eds., *Science, Technology and Welfare* (Washington, 1969), 3–24, at 15, reprinted (with original pagination) as chap. 9 of his *Science and Society* (Aldershot, 1994).

49 Some parish accounts in England still used Roman numerals into the seventeenth century: See W. P. D. Wrightman, *Science and the Renaissance*, 2 vols. (Edinburgh, 1962), i.90.

50 Robert Recorde, *Arithmetick; or, The Ground of Arts . . . augmented by John Dee, enlarged by John Mellis* (London, 1654), 10–26. See French, *John Dee*, 163–5.

51 Bacon will discuss Elyot in his *Of Tribute*. See James Spedding, ed., *Bacon: A Conference of Pleasure* (London, 1870). The text given in *Works* vii.119–43 is corrupt.

52 It is true that there were occasional attempts to integrate mathematics into the curriculum. In his *Positions, wherein those primitive circumstances be examined, which are necessarie for the training up of children, either for skill in their booke, or health in their bodie* (1581), Richard Mulcaster, the first headmaster of Merchant Taylor's School, calls for more time to be spent on the natural sciences (1888 ed. [London], 239–40); but this was an isolated call, and in any case it was issued in the context of a defence of the paramount importance of classical learning.

53 But possibly not, it should be noted, with that of his father Nicholas, to whom Thomas Digges, in the dedicatory letter to his edition of his father's *A Geometrical Practise, named Pantometria* (London, 1571), recalls Nicholas Bacon and Leonard Digges discussing geometry together.

54 *Adv. Learn.* II: *Works* iii.415.

and Arithmetic; the one handling Quantity continued, and the other dissevered. Mixed hath for subject some axioms or parts of natural philosophy, and considereth Quantity determined, as is the auxiliary and incident unto them. For many parts of nature can neither be invented with sufficient subtilty nor demonstrated with sufficient perspicuity nor accommodated unto use with sufficient dexterity, without the aid and intervening of the Mathematics: of which sort are Perspective, Music, Astronomy, Cosmography, Architecture, Enginry, and divers others. (*Adv. Learn.* II: *Works* iii.360)⁵⁵

This is really the sum total of what Bacon has to say on mixed mathematics, and his assessment of its role and standing is fleshed out revealingly in his attitude to astronomy. A few pages later, we are told that 'the same phenomena in astronomy are satisfied by the received astronomy of the diurnal motion and proper motions of the planets, and likewise by the theory of Copernicus who supposed the earth to move; and the calculations are indifferently agreeable to both.'⁵⁶ That this is not so much a criticism of Copernicanism but rather a general criticism of astronomy, considered as a mathematical discipline, is made clear in *De Dignitate & Augmentis Scientiarum*, where in discussing the Idols of the Tribe, he tells us that the human mind presupposes and assigns to nature greater equality and uniformity than there really is, taking as his example the contrivance of mathematicians in making all heavenly bodies move in perfect circles, instead of, say, spirals.⁵⁷ The point is reinforced in *Novum Organum*, where he stresses that he is constructing in the human understanding a true pattern of the world, 'quale invenitur, non quale cuiquam sua propria ratio dictoverit' – such as it is in fact, not such as our reason deems it to be.⁵⁸

After discussing mixed mathematics, Bacon moves on to an assessment of the general discipline of mathematics, which consists exclusively in highlighting the pedagogic features of pure mathematics:

In the Mathematics I can report no deficiency, except it be that men do not sufficiently understand the excellent use of the Pure Mathematics, in that they do remedy and cure many defects in the wit and faculties intellectual. For if the wit be too dull, they sharpen it; if too wandering, they fix it; if too inherent in the sense, they abstract it. So that as tennis is a game of no use in itself, but of great use in respect it maketh a quick eye and a body ready to

55 The division between geometry and arithmetic in terms of continuous and discontinuous magnitudes, a distinctive and core Aristotelian doctrine, is to be found in *Metaphysics* 1020a7–32 and elsewhere.

56 *Adv. Learn.* II: *Works* iii.365.

57 *De Aug.* V, chap. 4: *Works* i.644/iv.432. See the discussion in Hans Blumenberg, *The Genesis of the Copernican World* (Cambridge, Mass., 1987), 40–3.

58 *Nov. Org.* I, Aph. 124: *Works* i.218/iv.110.

put itself into all postures; so in the Mathematics, that use which is collateral and intervenient is no less worthy than that which is principal and intended. And as for Mixed Mathematics, I may only make this prediction, that there cannot fail to be more kinds of them, as nature grows further disclosed. Thus much of Natural Science, or the part of nature Speculative. (*Adv. Learn.* II: *Works* iii.360–1)⁵⁹

This marginal conception of mathematics is reflected in Bacon's classification of knowledge in the *Advancement of Learning* and *De Augmentis*. Generally speaking, it is far from clear that there are any real constraints imposed by his classification, for when he turns to individual subjects it is difficult to discern any substantive role.⁶⁰ That the classification commits him to very little at a substantive level is perhaps clearest in the case of the cosmetic and voluptuary arts, which Bacon certainly does not count as genuine knowledge at all, but which are included nonetheless.⁶¹ There are two significant exceptions, however, where he uses the classification in a revisionary way: to separate natural philosophy and theology, and to make sure that mathematics is assigned a strictly subsidiary role. The section on mathematics is designated an appendix to natural philosophy in *De Augmentis*, to remind us that its business is to serve natural philosophy, not to usurp it.⁶²

59 Such a conception is wholly in line with the very relaxed view of mathematics amongst the British gentry, for whom it was at best a diversion. As Mordechai Feingold points out, 'the vast majority of the upper classes pursued the mathematical sciences as one more accomplishment in a many-faceted, but by no means profound, education. The repeated recommendation of the "pleasing", "delightful", and "pretty" aspects of the mathematical sciences suggests that for many, even as part of the official curriculum, the study of mathematics was purged of the disciplined, often tedious, pursuit of abstract principles in favour of a relaxed pursuit of its more superficial attributes': *The Mathematicians' Apprenticeship: Science, Universities and Society in England, 1560–1640* (Cambridge, 1984), 192–3.

60 There is a strong contrast here with writers such as Aldrovandi, who did use an encyclopædic conception to organise at least the presentation of his results. See Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley, 1994), 57–70.

61 The cosmetic art is divided into a civil part – 'cleanness of body' – and an effeminate part, 'artificial decoration', which is dismissed as being both worthless and useless. As 'for the Arts of Sensual Pleasure, the chief deficiency in them is of laws to repress them' (*Adv. Learn.* II: *Works* iii.378). Compare the very different emphasis in Giambattista della Porta's *Magiæ Naturalis Libri Viginti in Quibus Scientiarum Naturalium Diuitiæ Demonstratur* (Frankfurt, 1597), which devotes Book IX to the theme of beautifying women (dyeing the hair, removing pimples, fastening one's teeth, etc.), and Book XI to how to make and apply perfumes.

62 *De Aug.* III, chap. 6: *Works* i.576/iv.369.

Eclecticism

There is often in Bacon a fluidity, an eclecticism, and an unwillingness to decide between what seem to be competing views, trying instead to balance them, as if in deciding between them we would inevitably lose something valuable in the view we decided against. Although eclecticism is something that disappeared from serious philosophy in the eighteenth century at the earliest, it is something alien to modern philosophy, and it is not easy for us to come to terms with it in its own right. The culture in which Bacon worked is permeated by it, however, and no real understanding of the bulk of English natural philosophy in the seventeenth century is possible without it. Bacon is working within a current of thought that not only has a Renaissance tradition behind it, but which extends further into the early-modern era than many commentators are prepared to admit. Moreover, the motivation behind some forms of what we can identify as eclecticism hinge on the practical nature of knowledge, whereas others do not, so it is important that we be clear about the kinds of eclecticism that were prevalent in early-modern natural philosophy in England, and identify what drives them.

Eclecticism was a feature of philosophy in the late Hellenistic, Roman, and early mediæval periods. Cicero, one of the principal sources of the moral philosophy of antiquity, presented this moral philosophy in a completely eclectic way, and Renaissance humanists from Petrarch onwards took over this eclecticism as part their approach to moral philosophy.⁶³ More generally, Roman thought, in which Stoicism was particularly important, was saturated with various forms of eclecticism and syncretism, and Stoic, Aristotelian, and Platonist doctrines were readily assimilated.⁶⁴ The most familiar case of syncretism is that of the various 'Platonist' schools, most notably the Middle Platonists and Neoplatonists,⁶⁵ and especially the Christian appropriation of Neoplatonic thought in Augustine and others in the formulation of a Christian metaphys-

63 Charles Trinkaus, *In Our Image and Likeness: Humanity and Divinity in Italian Humanist Thought*, 2 vols. (London, 1970), i.27; ii.768.

64 See Marcia L. Colish, *The Stoic Tradition from Antiquity to the Early Middle Ages, I: Stoicism in Classical Latin Literature* (Leiden, 1985), for the Roman uses of Stoicism.

65 John Dillon, *The Middle Platonists* (London, 1977), xiv–xv, argues that the Middle Platonist reconstruction of their philosophical sources is too coherent to be called eclectic, but the aim of the exercise, as his own subsequent analysis bears out, is reconciliation of doctrines rather than the defence of one at the expense of others. The defence of one doctrine at the expense of others was referred to (not necessarily pejoratively) as dogmatism in the Hellenistic era, and the Platonists were not treated as dogmatists.

ics and theology.⁶⁶ In the rediscovery in the West of Greek and Roman philosophical sources, from the twelfth century onwards, their eclectic approach is if anything reinforced. Renaissance Platonism took over elements from the Neoplatonists, Stoics, Aristotelians, Neopythagoreans, Gnostics, as well as initiates of mystery religions, alchemists, astrologers, and theurgists,⁶⁷ and Aristotelians were no different.⁶⁸

It is usual to see such features as being characteristic of a Renaissance 'mentality', yet forms of eclecticism not only are to be found in, but shape, natural philosophy in the sixteenth and seventeenth centuries, and they continue to play a significant role into the eighteenth century. It should be remembered in this context that ancient eclecticism was, following Diogenes Laertius,⁶⁹ taken seriously by some in the seventeenth century as having been a significant school of thought in antiquity with much to teach contemporary thought.⁷⁰ Paramount among these was Lipsius, who was one of the first to use the term 'eclecticism' in the modern era. Taking Seneca as his model, he advises that we should 'not

66 As Isaac Vossius was to point out in the seventeenth century, the Church Fathers had used the term 'eclecticism' to describe the procedure of correcting various doctrines of pagan philosophers in constructing a Christian philosophy: Isaac Vossius, *De Philosophia et Philosophorum Sectis* (The Hague, 1653), 222; cited in C. W. T. Blackwell, 'The Case of Honoré Fabri and the Historiography of Sixteenth and Seventeenth Century Jesuit Aristotelianism in Protestant History of Philosophy: Sturm, Morhof and Brucker', *Nouvelles de la Republique des Lettres* (1995), 49–77, at 53.

67 See Brian P. Copenhaver and Charles B. Schmitt, *Renaissance Philosophy* (Oxford, 1992), 136. On the details of Renaissance Platonism, see James Hankins, *Plato in the Italian Renaissance* (Leiden, 1994), and Trinkaus, *In Our Image and Likeness*.

68 As Schmitt points out, Renaissance thinkers blended together Aristotelianism with ideas taken from Plato, the Stoics, Cicero, Albertus Magnus, Aquinas, Duns Scotus, and Averroës into 'a spectrum of eclectic Aristotelianisms', and 'even beliefs as disreputable to modern eyes as magic and astrology attracted Renaissance philosophers such as Nifo, Achillini, and Pomponazzi whose orientation was predominantly Aristotelian, despite the fact that the textual basis in the Aristotelian corpus for such ideas was slim.' Copenhaver and Schmitt, *Renaissance Philosophy* (Oxford, 1992), 75–6. Chapter 4 of Charles B. Schmitt, *Aristotle and the Renaissance* (Cambridge, Mass., 1983) is devoted to eclectic Aristotelianism.

69 Diogenes Laertius, *Lives of Eminent Philosophers*, ed. and trans. R. D. Hicks, 2 vols. (Cambridge, Mass., 1925), Book I, 21.

70 It must be said, however, that the school was ignored in some influential and otherwise comprehensive histories, such as Stanley, *History of Philosophy*, where its absence is especially surprising given that work's claim to cover every sect, and its indebtedness to Diogenes Laertius. (The penultimate paragraph of the Preface, in the 1687 edition, is the place we would expect to find the 'leader' of the eclectics, Potamon, mentioned, if at all, as this corresponds to the relevant paragraph in Diogenes, and the structural parallels between the texts are very close.)

strictly adhere to one man, nor indeed one sect' and that the only sect we should follow 'is the Eclectic (let me translate it "Elective") which was founded by one Potamo of Alexandria'.⁷¹ The English natural philosopher Walter Charleton spells out his debt to this 'school' in no uncertain terms:

Our Fourth class is to be made up of those, who indeed adore no Authority, pay a reverend esteem, but no implicate Adherence to Antiquity, nor erect any Fabrick of Natural Science upon Foundations of their own laying: but, reading all with the same constant Indifference, and æquanimity, select out of each of the other sects, whatever of Method, Principles, Positions, Maxims, Examples, &c. seems in their impartial judgements, most consentaneous to *Verity*; and on the contrary, refute, and, as occasion requires, elenchically refute what will not endure the Test of either right *Reason*, or faithful *Experiment*. This sect we may call (as *Potomon Alexandrinus*, quoted by *Diogenes Laertius*, long before us) 'Ἐλεκτική', the ELECTING, because they cull and select out of all others, what they most approve. . . . Here to declare ourselves of this Order, though it be no dishonour, may yet be censured as superfluous: since not only those Exercises of our Pen, which have formerly dispersed themselves into the hands of the Learned, have already proclaimed as much.⁷²

And Boyle sets out his preference for a form of syncretism in a no less explicit way:

that sect seems to lay the most probable claim to the title of philosophy, that some call the *Potamonian* sect, others the *Eclectic*; since the professors of it did not confine themselves to the notions and dictates of any one sect, but in a manner include them all, by selecting and picking out of each that which seemed most consonant to truth and reason, and leaving the rest to their particular authors and abettors.⁷³

We find eclecticism in major figures in seventeenth-century English natural philosophy, such as Boyle and Newton, and in minor ones, such as Digby and Charleton. We find it in unorthodox figures like Dee and Fludd, and in orthodox ones like Cudworth and More. We find defences of English natural philosophy in continental Europe explicitly framed in terms of its eclecticism, as in Johann Christoph Sturm's *Philosophia*

⁷¹ Justus Lipsius, *Manducationis ad Stoicam Philosophiam Libri Tres* (Antwerp, 1604), 10; cited in Blackwell, 'Case of Honoré Fabri', 53. Potamo[n] was an Alexandrian living at the end of the first century B.C. who attempted to reconcile the doctrines of Plato, Aristotle, and the Stoics.

⁷² Walter Charleton, *Physiologia Epicuro-Gassendo-Charltoniana; or, A Fabrick of Science Natural, upon the Hypothesis of Atoms* (London, 1654), 4.

⁷³ *Appendix to the Christian Virtuoso*, in *Works of the Honourable Robert Boyle*, vi.700.

Electiva (Altdorf, 1686).⁷⁴ In the 1760s, Diderot, in his article on eclecticism in the *Encyclopédie*, associated the 'rediscovery' of eclecticism, as he sees it, with the birth of modern thought:

Eclecticism, the most reasonable of philosophies, which had been practiced by the first geniuses of mankind before it received its name, remained in oblivion until the end of the sixteenth century. Then nature, torpid for such a long time as if in a state of exhaustion, made an effort and finally produced some men who were jealous of the most beautiful prerogatives of mankind, the freedom to think for oneself. Eclectic philosophy was reborn with [Bruno, Cardano, Bacon, Campanella, Descartes, Hobbes, Leibniz, Thomasius. . .]⁷⁵

The virtue of eclecticism is its lack of association with any particular school:

The eclectic is a philosopher who, riding roughshod over prejudice, tradition, antiquity, universal consent, authority, in a word, everything that subjugates the mass of minds, dares to think for himself, goes back to the most clear and general principles, examines them, discusses them, allowing only that which can be demonstrated from his experience and his reason; and having analysed all philosophical systems without any deference or partiality, he constructs a personal and domestic one that belongs to him. I say a *personal and domestic philosophy* because the ambition of the eclectic is not so much to be the instructor of the human race as its disciple; not so much to reform others as to reform himself; to know the truth rather than to teach the truth. He is not a man who plants and sows; he is a man who reaps and sifts. . . . The sectarian is a man who embraces the doctrine of a philosopher; the eclectic, on the contrary, is a man who recognises no master.⁷⁶

Although its types and sources may vary, eclecticism is a very potent force in English seventeenth-century thought, and one of its principal representatives is Bacon. Among the various specific sources of eclecticism in English natural philosophy, one is particularly important, if difficult to assess in Bacon's case: the commonplace book. The best-known use of such commonplace books is in the realm of rhetoric, where they

74 See Blackwell, 'Case of Honoré Fabri'. More generally on the fortunes of eclecticism, see Ulrich Johannes Schneider, 'Eclecticism and the History of Philosophy', in Donald R. Kelley, ed., *History and the Disciplines: The Reclassification of Knowledge in Early Modern Europe* (Rochester, 1997); and Michael Albrecht, *Eklektik. Eine Begriffsgeschichte mit Hinweisen auf die Philosophie- und Wissenschaftsgeschichte* (Stuttgart/Bad Cannstatt, 1994).

75 Denis Diderot, *Encyclopédie, ou Dictionnaire raisonné des sciences, des arts et des métiers*, 17 vols. (Paris, 1751–65), v.283, col. 1. The article on eclecticism runs from v.270, col. 1, to v.293, col. 2, and the treatment is comprehensive.

76 Ibid., v.270, cols. 1–2.

served as places in which one jotted down – for later retrieval and use – passages, arguments, factual information, or turns of phrase that particularly struck one, although there are medical, travel, recipe, and other forms of such commonplace books common through the Middle Ages and Renaissance.⁷⁷ Natural philosophy was often pursued through such books in the Renaissance, and the model was Pliny's *Natural History*, which mixes myth, observation, and hearsay as well as information condensed from (by Pliny's own estimate) two thousand books.⁷⁸ Pliny's *Natural History* is one of the few ancient sources that Bacon praises, and although the genre of natural philosophy commonplace books has been relatively neglected until recently, it appears to have been a popular one, with Bodin's *Universae Naturae Theatrum* (1597) providing a Renaissance version of Pliny.⁷⁹ As one commentator has pointed out, Bodin used the commonplace book as an arsenal of 'tidbits of knowledge which he divorces from their original context in order to suit his own purposes.'⁸⁰

Although the use for which he intends them is different, Bacon too occasionally pursues natural philosophy by means of such commonplace books, most notoriously in his *Sylva Sylvarum*, which throws together materials from the same kinds of disparate sources that we find in Pliny, without regard for consistency.⁸¹ *Sylva Sylvarum* – 'a forest of materials' or 'a collection of collections' – consists of a thousand paragraphs, divided up into the ten 'centuries' of its subtitle, and each paragraph stating some fact, the majority of which are derived from ancient

77 See Ann Moss, *Printed Commonplace-books and the Structuring of Renaissance Thought* (Oxford, 1996).

78 See the discussion of Pliny in G. E. R. Lloyd, *Science, Folklore and Ideology: Studies in the Life Sciences in Ancient Greece* (Cambridge, 1983), 135–49, and in Roger French, *Ancient Natural History: Histories of Nature* (London, 1994), chap. 5.

79 See Ann Blair, 'Humanist Methods in Natural Philosophy: The Common-place Book', *Journal of the History of Ideas* 53 (1992), 541–51. See also the detailed account in her *The Theater of Nature: Jean Bodin and Renaissance Science* (Princeton, 1997). The persistence of the commonplace book and the seriousness with which it continued to be taken in the seventeenth century is indicated by the fact that John Locke's first published original work was 'A New Method of a Common-place Book', which introduced a new means of indexing the contents of such books (by first consonant and first vowel): *The Works of John Locke Esq.*, 2d ed., 3 vols. (London, 1722), iii.481–95. (The first appearance of the piece was in French translation in Jean Le Clerc's *Bibliothèque universelle et historique* in 1686.) On the later history of commonplace books and their connection with natural science, see Richard Yeo, 'Ephraim Chamber's *Cyclopaedia* (1728) and the Tradition of Commonplaces', *Journal of the History of Ideas* 57 (1996), 157–75.

80 Blair, 'Humanist Methods', 545.

81 See the discussion in Graham Rees, 'An Unpublished Manuscript by Francis Bacon: *Sylva Sylvarum* Drafts and Other Working Notes', *Annals of Science* 38 (1981), 377–412.

authors such as Aristotle or Pliny, or more recent authors such as della Porta,⁸² Cardan, Scaliger, or Sandys.⁸³ Well over half of it – generally speaking, all sections except those dealing with music and sound, or plants, and some of the discussion of spirit and virtues – employs principles of selection that seem recklessly indiscriminate. Moreover, the reliability of much of the information presented and its intrinsic importance are questionable, the explanations given are often quite perfunctory; vast portions of it throw no light either on Bacon's own natural philosophy or on any other of his original enterprises. Significantly, *Sylva Sylvarum* does not even confine itself to things that Bacon considers true or plausible: When reporting various sympathies and antipathies between those who are blood-related, friends, and enemies, for example, his tone is apologetic, telling us that 'the sympathy of individuals, that have been entire, or have touched, is of all others the most incredible; yet according unto our faithful manner of examination of nature, we will make some little mention of it.'⁸⁴ The work is much more on a par with the sixteenth-century, Pliny-inspired 'natural history' accounts of della Porta, Cardan, Wecker, or Bodin. In his writings such as *Novum Organum*, Bacon went beyond these, albeit not so decisively as to establish a taste for his own, more profound version of the discipline, so that the outdated genre of *Sylva Sylvarum* could flourish while *Novum Organum* went comparatively neglected: After the *Essayes*, *Sylva* was the most widely read text by Bacon in the seventeenth century, passing through sixteen English and three Latin printings/editions between 1626 and 1685 (compared with four printings/editions for *Novum Organum* in this period, for example),⁸⁵ and it was a central source of inspiration for many later seventeenth-century writers.⁸⁶

82 Della Porta, *Magiæ Naturalis*, is Bacon's main source.

83 Paragraphs 701–60 of *Sylva* follow closely George Sandys, *A Relation of a Journey Begun An: Dom: 1610* (London, 1615): See Ellis's preface to *Sylva Sylvarum*, Works ii.327.

84 *Sylva* X ¶1997: Works ii.669.

85 For bibliographic details, see R. W. Gibson, *Francis Bacon: A Bibliography of His Works and of Baconiana, to the Year 1750* (Oxford, 1950). Note that the usual date given for the first edition of *Sylva Sylvarum* is 1627, but Gibson records a 1626 edition, of which the 1627 version simply has a new title page, everything else being identical.

86 Note the Eulogy of *Sylva Sylvarum* in Walter Blith's *The English Improver; or A New Survey of Husbandry* (London, 1649)

Sir Francis Bacons Naturall Historie let it have high esteeme, t'is full of Rarities and Admiration for true Philosophie, and shall be acknowledged A Sunne in the Theore, to these poore and lowe Moone'light discoveries. ('Epistle', p. 3)

Thomas Blount's *A Natural History: Containing Many not Common Observations: Extracted out of the best Modern Writers* (London, 1693) quotes frequently from *Sylva Sylvarum*, and John Worlidge, *Dictionarium Rusticum & Urbanum* (London, 1704), cites it as one of his source books.

The compilation of material is an important part of Bacon's project, and in *De Dignitate & Augmentis Scientiarum* he offers an explicit defence of commonplace books, provided the collection of materials from them can be reformed along his own lines:

[T]here can hardly be anything more useful even for the old and popular sciences, than a sound help for the memory; that is a good and learned Digest of Common Places. . . . I hold diligence and labour in the entry of common places to be a matter of great use and support in studying; as that which supplies matter to invention, and contracts the sight of the judgement to a point. But yet it is true that of the methods and frameworks of common places which I have hitherto seen, there is none of any worth; all of them carrying in their titles merely the face of a school and not of a world; and using vulgar and pedantical divisions, not such as pierce to the pith and heart of things. (*De Aug.*, Book 5, chap. 5: *Works* iv.435)⁸⁷

Nevertheless, in many respects, the role of the commonplace book is the most difficult to assess of the models for Bacon's natural philosophy. In particular, we must be careful not to run together various uses of commonplace books, and Bacon's indebtedness to the genre does not extend as far as the attempt to build up one's arguments from a patchwork of quotes and borrowings from ancient sources. This subgenre, known in the early seventeenth century as *cento*, finds notable exponents in Lipsius – who tells us that he aims to offer instruction 'not by my owne sayings, but by the precepts of ancient authors, delivered also in their own wordes'⁸⁸ (in reference to which one seventeenth-century wit pointed out that Lipsius put nothing of his own into his *Politics* except the adverbs and conjunctions)⁸⁹ – and in Burton, who starts out by telling us the following:

As a good house-wife out of diverse fleeces weaves one piece of cloth, a bee gathers wax and honey out of many Flowers, and makes a new bundle of all,

87 The use of commonplaces is not discussed in any detail in Bacon, although a fragment – 'Of the Colours of Good and Evil', which is appended to the 1597 edition of the *Essayes* (*Works* vii.77–92), and reappears in 1623 as part of Book 6 of *De Augmentis* (*Works* i.674–88) – does deal with the question briefly, and his term 'colours' refers to general precepts of argument, or commonplaces. See Jardine, *Francis Bacon: Discovery*, 219. Cf. Quentin Skinner, *Reason and Rhetoric in the Philosophy of Hobbes* (Cambridge, 1996), 115–16.

88 Justus Lipsius, *Sixte Books of Politickes or Civil Doctrine*, trans. William Jones (London, 1594). Cited in Skinner, *Reason and Rhetoric*, 118, who discusses the genre. On how exactly Lipsius should be read, see Ann Moss, 'The *Politica* of Justus Lipsius and the Commonplace-book', *Journal of the History of Ideas* 59 (1998), 421–36.

89 François Ogier, *Apologie pour Monsieur de Balzac* (Paris, 1628), 23; quoted in Timothy Reiss, *Knowledge, Discovery and Imagination in Early Modern Europe* (Cambridge, 1997), 149 n. 44.

Floriferis ut apes in saltibus omnia libant, I have laboriously collected this cento out of various writers . . . [but] I cite and quote mine authors . . . *sumpsi, non surripui*.⁹⁰

This genre is not wholly alien to Bacon, as those accounts which (encouraged by Bacon's own occasional abuse of the ancients) stress his opposition to earlier thought might have us believe, but nor is it his *modus operandi*. Sometimes commonplaces seem to function as the skeleton on which he builds even if this building is minimal, as in the short aphoristic writings and in *Sylva Sylvarum*. On other occasions, as in *Novum Organum* or the core material for the 'Great Instauration', there seems to be quite a schematic skeleton which is fleshed out in terms of commonplaces (in the form of uncontentious information selected from ancient authors, for example), among other things.

Practical concerns motivated by the recording and presentation of information, evident in the genre of commonplace books, carries over into the definitive presentation of information, leading him to tailor questions of method of presentation to practical application or use.⁹¹ When he sets out what he regards as the fundamentals of legal reasoning in the Preface to his *Maxims of Law*, for example, he writes:

Whereas I could have digested these rules into a certain method or order, which, I know, would have been more admired, as that which would have made every particular rule, through this coherence and relation into other rules, seem more cunning and more deep; yet I have avoided to do this, because this delivering of knowledge in distinct and disjointed aphorisms doth leave the wit of man more free to turn and toss, and to make use of that which is so delivered to more several purposes and applications. (*Works* vii.321)⁹²

90 Robert Burton, *The Anatomy of Melancholy*, 2 vols (1st ed., 1621; London, 1826): i.11.

91 This Baconian approach to commonplace books was developed into a model for natural history field notebooks in the eighteenth and nineteenth centuries. George Graves, for example, in his *Naturalist's Pocket-Book or Tourist's Companion* (London, 1819), writes, in a passage that could be straight out of Bacon:

[I]t is not by mere accumulating [of] a large variety of curious species that the science is advanced, but it is by acquiring a knowledge of the habits and propensities, the contrasts, the similarities, the uses or injuries they offer to mankind, that gives life and spirit to the science; and in fact is the true and only real use of the study. (126–7)

Graves provides sample illustrations from his own field notebook on how to organise the material. What we have, in effect, is a specialised commonplace book compiled along Baconian lines. See Ann Larsen, 'Equipment for the Field', in N. Jardine, J. A. Secord, and E. C. Spary, eds., *Cultures of Natural History* (Cambridge, 1996), 358–77.

92 See also his remark in the *Parasceve* that 'too much method produces iterations and prolixity' (*Works* i.395/iv.253). Cf. *Valerius Terminus*, where Bacon speaks

One important corollary of Bacon's adherence to various forms of eclecticism is his rejection of a single method for presenting results. Despite his frequent criticisms of lack of system in other writers, he does not himself always recommend 'methodical' or systematic means of presentation. This is really rather crucial for our understanding of his general conception of how one should proceed fruitfully in natural philosophy, for methodological questions about discovery and presentation are not always clearly separate in Bacon. To discover the motivation behind his concern with methodological questions, we need to look at the sources of his conception of method. These lie in what turn out to be three related concerns: rhetoric and an attempt to reform the law, which we shall address in Chapter 2, and an understanding of the political legitimacy of knowledge claims, to which I shall turn in the context of a general discussion of the sources of legitimacy of natural philosophy in Chapter 3.

Note 92 (*cont.*)

approvingly of 'publishing in a manner whereby it shall not be to the capacity nor taste of all, but shall as it were single and adopt his reader' (*Works* iii.248). There were a number of classical precedents for rejecting any fixed order, the most important being Cæselius Vindex, who was followed in antiquity by writers such as Aulus Gellius, and in the sixteenth century by writers such as Cælius Rhodiginus. See Blair, *Theater of Nature*, 38–9.

Humanist models for *scientia*

The idea of mathematics or mechanics as a model for natural philosophy was something that took shape gradually during the seventeenth century. By contrast, during the Renaissance the models were taken from a variety of areas in which argument, persuasion, discovery, and the many other things that one expected of natural philosophy were pursued. Law and textual criticism figured predominantly here, for these were areas in which major reforms were being introduced and which were continuing to yield benefits.¹ For Renaissance thinkers – even those who, like Bacon, can take a significant share of the responsibility for the transition to modernity – it is above all the legal-rhetorical tradition that shapes their theoretical sensibilities.² In the first instance, Bacon set out not to reform natural philosophy but to reform law and, through this, politics. His shift from the reform of law to the reform of natural philosophy is possible and, in a way that is initially very difficult for us to understand, natural, because what Bacon sees as the problems in law and natural philosophy have a number of shared – or at least analogous – sources. These sources are something embedded in English Renaissance culture, and Bacon very largely uses the resources of that culture to unearth and transform them. Consequently, our first priority must be that culture.

An education in rhetoric

Bacon was born into one of the most illustrious families in England. His father, Sir Nicholas Bacon, although from humble origins, was Lord-

1 See Donald R. Kelley, *Foundations of Modern Historical Scholarship: Law and History in the Renaissance* (New York, 1970), and Ian Maclean, *Interpretation and Meaning in the Renaissance: The Case of Law* (Cambridge, 1992).

2 I have argued elsewhere that this is true even of the early Descartes, whose break with Renaissance thinking is far more radical than Bacon's: See my *Descartes, an Intellectual Biography* (Oxford, 1995), 115–24.

Keeper of the Great Seal of England, and was both eloquent and cultured.³ He was ranked by one of his contemporaries, Thomas Nashe, with Philip Sidney and Thomas More as one of 'the chiefe pillars of our English speech';⁴ and George Puttenham, in his *The Arte of English Poesie* (1589), noted that he found him 'sitting in his gallery alone with the works of Quintilian before him.'⁵ He was noted for his apophthegms, some of which Bacon included – along with those of Pericles, Alexander, Cicero, Laud, and others – in a collection of apophthegms which he brought out in 1624.⁶ The large house he had built at Gorhambury in Hertfordshire, to which Queen Elizabeth was a regular visitor, evidently had a well-equipped library as well as a banqueting hall depicting the liberal arts, and the painting of Ceres introducing the sowing of grain, which hung over the fireplace of the hall, carried the motto *Monita Meliora* ('instruction brings improvement').

His mother, Anne, was daughter of Sir Edward Coke, who had been tutor to Edward VI. One of her sisters was married to the secretary of state, Sir William Cecil (later Lord Burghley), who will play a key role in Bacon's subsequent political career; the other to Sir Thomas Hoby, who translated Baldassare Castiglione's *Il libro del cortegiano*, the most important and popular Renaissance treatise on education in manners and behaviour, into English. Anne herself was no stranger to serious scholarship, and during 1564, for example, when Francis was three years old, we find her preparing a Latin translation of Bishop Jewel's *Apology for the Church of England*.⁷

3 On Sir Nicholas Bacon, see Lisa Jardine and Alan Stewart, *Hostage to Fortune: The Troubled Life of Francis Bacon 1561–1626* (London, 1998), chap. 1.

4 Thomas Nashe, *Pierce Penilesse his supplication to the Deuill* (London, 1592), D3^r.

5 George Puttenham, *The Arte of English Poesie* (London, 1589), R^r.

6 *Apophthegms, Old and New* (published 1624, dated 1625): *Works* vii.123–65. This culture of writing or speaking in apophthegms or aphorisms, where information is presented in a concentrated and striking way, often with a view to ease of memorisation and meditation, is, as we shall see, one that Bacon will make his own.

7 The translation was so good that Jewel considered it to be better than his English original, and it became the 'official' version of the book. Anne was an intelligent, well-read woman of strong beliefs and an equally strong will, and it is likely that it was she, rather than Bacon's father, who played the more dominant part in the upbringing of her sons. Frank E. Manuel and Fritzie P. Manuel point out in their *Utopian Thought in the Western World* (Cambridge, Mass., 1970), that 'when her sons were over thirty, Anne Bacon still treated them as minors. Her letters . . . afford an inkling into their upbringing. There are outbursts of verbal violence, curses, followed by effusive concern, admonitions against what might injure their health, presents of delicacies they liked to eat and home-brewed beer to strengthen them' (245).

Francis was the younger of two sons (the elder being Anthony) and received private tuition at Gorhambury:⁸ we can assume the usual accomplishments, among which a good command of Latin authors,⁹ with knowledge of writers such as Ovid, Horace, Virgil, and possibly Cicero and Melanchthon, as well as a knowledge of the Bible, would have figured largely. In April 1573 they were sent to Trinity College, Cambridge, where they shared rooms. Gorhambury was only a few hours' ride from Cambridge, and as well as spending holidays there, and the period between August 1574 and March 1575 when the university was visited with the plague, it is possible that the boys would occasionally have ridden to Gorhambury during term time. There is no case to be made that Francis Bacon was immersed in the life of Cambridge during his time there. Moreover, it should also be noted that he was only twelve when he went to Trinity College, and fourteen when he left in December 1575, so however precocious he might have been (and we have no reason to suppose that he was especially precocious – the Master refers to the boys simply as good students), we must bear in mind his youth in asking what he might have learned there, or how the intellectual culture at Cambridge might have affected him.

William Rawley, who became his chaplain and amanuensis when Bacon became Lord Chancellor in 1618, and who remained a friend after Bacon lost this post in 1621 until his death, writes in his *Life of Bacon* that Bacon had recounted his aversion to Aristotle in his university years,

not for the worthlessness of the author, to whom he would ever ascribe all high attributes, but for the unfruitfulness of the way; being a philosophy (as his lordship used to say) only strong for disputations and contentions, but barren of the production of works for the benefit of the life of man; in which mind he continued to his dying day. (*Works* i.4)¹⁰

8 His tutor from 1566 to at least 1569 was John Walsall: See Virgil B. Heltzel, 'Young Francis Bacon's Tutor', *Modern Language Notes* 63 (1948), 483–5.

9 Brian Vickers, in his 'Bacon and Rhetoric', in Markku Peltonen, ed., *The Cambridge Companion to Bacon* (Cambridge, 1996), 200–31, points out that the brothers would have gone through the whole of the primary- and grammar-school curriculum before they went to Cambridge (p. 205), and he uses the reconstruction of the curriculum offered in T. W. Baldwin, *Shakespeare's Small Latine and Lesse Greeke* (Urbana, 1944) to indicate what they would have studied.

10 Bacon's aversion to Aristotle should be seen in the context of the overwhelming authority Aristotle had. The statutes of Oxford University, for example, decreed that 'Bachelors and Masters who did not follow Aristotle faithfully were liable to a fine of five shillings for every point of divergence, and for every fault committed against the Logic of the Organon.' Quoted in Richard Foster Jones, *Ancients and Moderns: A Study of the Rise of the Scientific Movement in Seventeenth-Century England* (New York, 1982), 4.

It is difficult to take this account at face value: What kind of aversion to Aristotle would a fourteen year old¹¹ be likely to have had in these circumstances? The curriculum he followed at Cambridge was not contentious in general outline. Like students in the universities of continental Europe, Bacon's principal area of study was the *trivium*, that is, grammar, rhetoric, and dialectic, with the overwhelming emphasis on Latin authors. His tutor, Whitgift, kept records of the books he purchased for the boys, and these included philosophical works by Aristotle, Plato, and Cicero, rhetorical works by Cicero, Demosthenes, and others, and the histories of Xenophon, Caesar, and Sallust.¹² Considerably less time, if any, would have been spent on the *quadrivium* – geometry, arithmetic, astronomy, and harmonic theory – and he would probably have received little instruction in ethics, metaphysics, and natural philosophy, which were largely reserved for more advanced students. Nevertheless, there were certainly contentious issues in Cambridge in Bacon's time, and one dispute that affected everyone was that over the educational reforms of Ramus, reforms which had extensive implications for the nature of traditional learning. While it is difficult to accept that Bacon had any direct knowledge of, or interest in, the specifics of these debates,¹³ they do indicate to us just what questions were regarded as the key ones in Bacon's time at Cambridge.

The issues in dispute were both complex and confused, but a core question at stake was that of the acquisition of knowledge.¹⁴ The problem was one which had in fact dogged the history of Aristotelianism, especially in its later stages. Simplifying radically, we can break the question up into its origins in Aristotle, its transformation into a serious problem through later misinterpretations of Aristotle, and the attempt to respond to the problem thereby generated by making a new separation between the acquisition of knowledge and its presentation. In earlier writings such as the *Topics*, Aristotle had elaborated procedures for the 'discovery of knowledge'. These procedures were designed to guide one in uncovering the appropriate evidence, discovering the most fruitful

11 Rawley relates that Bacon was 'about sixteen years of age' at the time, which cannot be right.

12 See Philip Gaskell, 'Books Bought by Whitgift's Pupils in the 1570s', *Transactions of the Cambridge Bibliographical Society* 7 (1979), 284–93.

13 Cf. *Adv. Learn.* II: *Works* iii.326:

And therefore in as much as most of the usages and orders of the universities were derived from more obscure times, it is the more requisite they be re-examined. . . . [One example is] that scholars in universities come too soon and too unripe to logic and rhetoric; arts fitter for graduates than children and novices.

14 I look at some aspects of this problem, and Descartes's reponse to it, in my *Cartesian Logic* (Oxford, 1989).

questions to ask, and so on, and they did this by providing devices or strategies for classifying or characterising problems so that they could be posed and solved using set techniques.¹⁵ In his later works such as the *Analytics*, however, there is a marked change of emphasis: Aristotle now pursues the question of the presentation of results, as his concerns shift to the validity of the reasoning used to establish conclusions on the basis of accepted premises. In other words, his concerns shifted from questions of discovery to questions of demonstration. Although this is not problematic in itself, it became so in the light of subsequent developments, for what happened, in the course of later thinking about the nature of discovery and demonstration, was a twofold displacement of the original problem. First, Aristotle's method of demonstration – syllogistic – came to be construed as his method of discovery, and various procedures, most notably that of resolution and composition, were introduced to show how we can order our experience in such a way that it yields fundamental rational principles which reflect the way things are in nature. The problem of the discovery of knowledge becomes largely subsumed under the question of the organisation of knowledge. Second, the original method of discovery, the topics, disappears from the scientific context altogether, although the topics do retain an importance in rhetoric. The final stage comes with the attempts of various sixteenth- and seventeenth-century thinkers to prize open the distinction between discovery and presentation, and to offer an independent account of discovery.

One such attempt was that of Ramus, although his approach to the topics is shaped by distinctively sixteenth-century humanist interests, so that it is in no sense a return to Aristotle, and in fact ends up looking very different from Aristotle's concern with the topics. Ramus thinks of knowledge in exclusively pedagogic terms, transforming the topics into a system of pedagogic classification of knowledge: The point of the exercise is to enable us to refer any question back to the storehouse of ancient wisdom, the role of the topics being to provide us with points of entry into this storehouse.¹⁶ Ramus's approach had no monopoly in attempts to deal with this question, but it did manage to engage (coherently or otherwise) a very broad range of questions – about the relative standing

15 Bacon describes the use of the topics, or 'places', in these terms in Book 2 of the *Advancement of Learning*:

But the same Places which will help us what to produce of that which we know already, will also help us, if a man of experience were before us, what questions to ask; or if we have books and authors to instruct us, what points to search and revolve. (*Works* iii.391)

16 See the discussion in Walter J. Ong, *Ramus, Method and the Decay of Dialogue* (Cambridge, Mass., 1983).

of various disciplines, the aims of pedagogy, and the nature of knowledge – which had become problematic in the course of the sixteenth century. There may also have been political and ideological overtones to Ramus's success in England in the 1570s: He was, after all, a Protestant martyr, murdered in the Saint Bartholomew's Day Massacre, a fact advertised on the title page of the 1574 English translation of his *Logic*.¹⁷

Five years after Bacon left Cambridge, matters came to a head, and a bitter public dispute erupted over the relative merits of Aristotle and Ramus,¹⁸ prompted by the publication in 1580 by Everard Digby, a leading spirit in the revival of Aristotelianism in England, of *De Duplici Methodo*, a pamphlet attacking Ramism from an Aristotelian perspective. The response came in two works from the Ramist William Temple, *Admonitio de Unica P. Rami Methodo* (1580) and *Pro Mildapetti de Unica Methodo* (1581).¹⁹ Following Aristotle, Digby makes a sharp distinction between what is 'better known to us', which is a function of our limited experience, and what is 'better known in nature', that is to say, the most general precepts underlying the discipline under consideration, precepts which enable us to grasp the universal principles around which the discipline is structured. This distinction motivates his accounts of pedagogy, invention or discovery, and judgement, the idea being that we must start from what is better known to us and work towards, or – in the all-important case of the pedagogical context – be guided towards, what is better known in nature. This guidance takes the form of the methods of resolution (analysis of a problem into its elements) and composition (construction of a solution out of these elements), all this being done in the context of a syllogistic formulation of all knowledge.

Temple responds with a straightforward rejection of the distinction between 'better known to us' and 'better known in nature', arguing that one kind of knowledge can be said to be prior to another only if the one is needed to explain the other, and such priority resides resolutely with the most general precepts. Then, making a sharp distinction between invention or discovery and demonstration, he argues that the former has nothing to do with the syllogistically motivated procedures of resolution and composition, but depends simply on observation and inferences from such observation (induction). As regards demonstration, he argues that it is irrelevant how knowledge is acquired: All that matters is how

17 *The Logike of the Most Excellent Philosopher P. Ramus Martyr* (London, 1574).

18 See Lisa Jardine, *Francis Bacon: Discovery and the Art of Discourse* (Cambridge, 1974), chap. 2, to which my account here is indebted.

19 I have selected the most important pamphlets. Digby and Temple each wrote a number of pamphlets, attacking and counterattacking the other, as was usual in these disputes. See Jardine, *Francis Bacon: Discovery*, 60 n. 1, for the full titles and chronological sequence of pamphlets.

it is best conveyed, and this will be the same in all pedagogic circumstances, for it will always consist in the move from the more general to the less general.

Now the importance of these disputes for us lies not in any effect they may have had on Bacon, but in the extent to which they indicate to us what issues might have been seen as the key ones during the time that Bacon spent at Cambridge. With his brother, he was placed under the personal tutelage of the Master of Trinity, Dr John Whitgift. Whitgift, a staunch defender of the established church who devoted some considerable time to rooting out nonconformists in the university, was resolutely opposed to Ramus, and we can be reasonably sure that none of the latter's writings would have passed through the boys' hands; nor do we have any grounds for thinking that they would have been directly aware of the disputes over Ramism at the time. Nonetheless, the very fact that questions of demonstration and discovery were the disputed questions during his time at Cambridge suggests that it was such issues that occupied the thinking of tutors such as Whitgift, and that, if particular emphasis were given to anything in the broad curriculum studied, we might expect these issues to be foremost among them. It is sometimes argued that Bacon's philosophical education at Cambridge can have had no effect on his thinking for, it is maintained, there is a gap of about twenty-five years between his time in Cambridge and his first philosophical writings, which seems to indicate that his interest in philosophy was a later development. However, in a letter of 1625 Bacon refers to a writing which he dates to around 1585,²⁰ entitled *Temporis partus maximus*; this work is no longer extant, but it may well have been an early draft of the rabidly anti-Aristotelian *Temporis partus masculus* (c. 1602), in which case he may have picked up a certain approach to what he identified as Aristotelian philosophy, which he only began to articulate later: this would, of course, also fit Rawley's explicit statement that Bacon told him of his aversion to Aristotle in his university years.²¹ That his dissatisfaction with Aristotle was due to an acquaintance with Ramus is not something that we can plausibly claim; but that he did have an early dissatisfaction, and that the issues to which he would have been particularly exposed – key philosophical issues for him in his later writings on natural philosophy – were those surrounding discovery and demonstration does seem likely.

20 Letter to Fulgentium, 1625: *Works* xiv.532. He tells Fulgentium that forty years earlier he had composed a juvenile work with 'the magnificent title' of *Temporis partus maximus*.

21 Note also the criticisms of the 'philosophy of the Grecians' in the 1592 'In Praise of Knowledge', *Works* viii.124.

All the same, Bacon's predominant interests over the next twenty years will indisputably be in the law and politics, and it was without doubt preparation for such areas that his parents had in mind when they sent him to Cambridge in the first place. The study of the liberal arts underlay a remarkably broad range of areas, including law and politics, on the one hand, and the issues of scientific demonstration and discovery on the other, and the most crucial part of the liberal arts in this respect was rhetoric. Since it is this that underlies, and helps us make sense of, the transition from politicolegal reform to the reform of natural philosophy, it is of some importance that we understand, at least in outline, in what sense these areas can be pursued via rhetoric and the liberal arts generally.

The office of the philosopher

At its most general level, the task of rhetoric was the formulation, organisation, and expression of one's ideas in a coherent and compelling way. It was designed to help one find one's way around the comprehensive body of learning built up from antiquity, to recognise where appropriate evidence and arguments might be found, to provide models which were designed to give one a sense of what was needed if a particular question was to be investigated, or a particular position defended, models that would be shared with those to whom one was expounding or defending one's case. It was designed to help one focus one's mental powers in various ways, to organise one's thoughts in the most economical fashion, and even (in writers like Quintilian) to provide vivid images or representations of situations that enabled one to convince oneself of a case (important especially in acting and in legal argument). It was designed to provide models to show one how particular kinds of case were best defended, depending on such facts as the availability of and complexity of the evidence, and the state of knowledge in /opinions of /prejudices of the audience towards which one was directing one's arguments. At a general level, rhetoric was indifferent as to subject matter, in that very comprehensive procedures were recommended that would aid one's investigations or one's case irrespective of whether one were conducting a scientific investigation or a legal one, although at a specific level there would be similarities or analogies (as regards the standing of various kinds of evidence, for example) and dissimilarities (as regards the means by which one collected evidence, for example) between legal cases and those in natural philosophy. The law, taken in a broad sense, was very much a paradigm case for rhetorical writers: Rhetorical treatises were often seen explicitly as being directed towards lawyers and legislators, and examples were geared around the kinds of problem case that arose in law. In the light of this, it is only to be expect-

ed that using a rhetorical model for knowledge – that is, a model that gives direction on how to collect and assess evidence for a view, how to make a judgement on the basis of that evidence, and how to establish the correctness of one's judgement, using precepts derived from the study of rhetoric – is in many respects using a legal model. These connections, as we shall see, are particularly strong in the case of Bacon's attempts to reform natural philosophy.

However, there is another, equally important side to the question which has gone comparatively unnoticed, and in which law plays no significant role. Given the part that rhetoric played in education, it also served to mark out the educated from the uneducated. More generally, in the sixteenth and seventeenth centuries, it was closely bound up with questions of appropriate manners and appropriate behaviour.²² As such it served in the formation of a self-image of professional and other groups. Such groups were undergoing significant changes in the sixteenth and seventeenth centuries, and at a general level the point hardly needs stressing; for, whatever disagreements there may be over points of detail, it is widely accepted that the science and philosophy of the seventeenth century inaugurated a new era in philosophical and scientific thinking. What is also relevant here, however, is the way in which various professional groups forged an identity for themselves, and this is an issue that is especially important for our understanding of how Bacon wishes to reform natural philosophy by reforming its practitioners.

We can structure our discussion around two contrasts: the first, that between *negotium* and *otium*, derives from a revival in Italian humanist authors of certain classical questions about the responsibilities of the humanist. The second, that between the philosopher and the poet, a dispute that has its *locus classicus* in Book 10 of Plato's *Republic*, raises the question of who is best placed to lay claim to an understanding of the world.

Bacon's education was that of a statesman, whether at Gorhambury, Cambridge, or subsequently at Gray's Inn or the French court. It had the ultimate aim of practical training in affairs of state. In 1575, at the age of fourteen, Bacon left Cambridge, with his brother, for Gray's Inn, where his study of law began. This study was interrupted in 1576, when he was placed under the tutelage of Sir Amias Paulet, who was appointed ambassador to the French court in September of that year. Bacon accompanied him to France and lived there until February 1579. The aim of send-

22 Such tightly bound codes of conduct are almost invariably accompanied by parodies – perhaps the most famous being the late-mediaeval French 'carnivals'. Sixteenth-century England was no exception, and Bacon himself provided a parody of manners in a piece for the Gray's Inn revels at the beginning of 1595: See his 'Gesta Grayorum': *Works* viii, 329–42

ing young men to accompany ambassadors is set out by Bacon in 1616 in a letter of advice to Sir George Villiers. Elizabeth's practice, he writes, had been to send, to accompany the ambassador, 'some towardly young noblemen or gentlemen . . . as assistants or else attendants, according to the quality of the persons; who might be thereby prepared and fitted by this means for the like employment another time.'²³ One of the main roles of ambassadors and their assistants was to gather political intelligence, and Bacon was sent there to receive a practical education in politics. His mentor, Paulet, was one of England's staunchest Puritans, a fierce opponent of Mary Stuart (later appointed her gaoler by Elizabeth), and much closer to Bacon's mother's strong Protestant sympathies than Whitgift had been.²⁴

The political nature of the appointment raises the question of the extent to which Bacon may have become familiar with continental political debates while in France. He would have spent most of his time in Paris, and it is likely that he would have come into contact with a group, associated with the French court, who were debating the republican ideas issuing from Italy: Paulet's predecessor had in fact complained about the regularity with which this group met with the French king.²⁵ It was Italian republican ideas, most notably those of Guicciardini and Machiavelli, that informed political debate more generally throughout much of Europe in the sixteenth and early seventeenth centuries.²⁶ They had spread northwards from the end of the fifteenth century and can be found in England in works like More's *Utopia* (1516) and Thomas Star-

23 Letter of Advice to Villiers, second version: *Works* xiii.42. Cf. first version, *Works* xiii.20.

24 We know that he spent time in Paris, Blois, Tours, and Poitiers, but we have no details of his activities. His brother Anthony, who spend the period from the end of 1579 to the beginning of 1592 in France (with a short stay in Geneva), did leave records of his activities, however, and he was clearly an agent of Walsingham's, devoting much of his time to gathering political intelligence. Anthony had a more independent hand than his brother, as he was an adult and was not attached to an ambassador, but it serves as a reminder that immersion in the cauldron of Western European politics was not a pretext for a 'Grand Tour': It was a serious business. This episode in the lives of Francis and Anthony has now been set out in detail in chaps. 2 and 3 of Jardine and Stewart, *Hostage to Fortune*.

25 See Julian Martin, *Francis Bacon, the State, and the Reform of Natural Philosophy* (Cambridge, 1992), 27–8.

26 On Italian republican ideas, see Hans Baron, *The Crisis of the Early Italian Renaissance* (Princeton, 1966). On the spread of Italian political ideas to the rest of Europe, see J. G. A. Pocock, *The Machiavellian Moment: Florentine Political Thought and the Atlantic Republican Tradition* (Princeton, 1975); Thomas F. Mayer, *Thomas Starkey and the Commonweal* (Cambridge, 1989); and Quentin Skinner, *The Foundations of Modern Political Thought*, 2 vols (Cambridge, 1978).

key's *Dialogue between Reginald Pole and Thomas Lipset* (c. 1535), although the latter, written in Italy, was only published in the seventeenth century. It should be said that the republicanism of the Italian ideas was not something that necessarily implied hostility towards the monarchy, and so had a wider appeal than its nomenclature might suggest, and the somewhat more conservative northern European humanists took up the fundamental ideas of this new political theory. Two predominant issues in the Italian tradition that were universally taken over by northern humanists are the importance of sound learning for sound government, and the responsibilities of humanists to provide such sound learning in the practical context of government. The latter, taking its starting points from the first book of Aristotle's *Nicomachean Ethics* and more generally from the concerns of the Stoics, raised the question of the responsibilities appropriate to the humanist, in particular whether the life of activity in affairs of state (*negotium*) should be preferred to that of detachment and contemplation (*otium*). This question had been put in More's *Utopia*, which, having been continuously in print since its publication in 1516, set the agenda for English thinking on the question. The answer almost invariably²⁷ (albeit in some cases reluctantly) given – not least by Bacon himself, in Book 7 of *De Augmentis*²⁸ – was that *negotium* should be preferred to *otium*, and the kind of learning at issue included as a central component the rhetorical tradition, which was meant to provide insights into everything from public administration and the formulation of law, to the reform of armies.²⁹

Once this question had been decided, the issue then became not just the appropriate learning but also, given the practical nature of the programme, the appropriate behaviour of such a practical humanist, which

27 Among the more important exceptions are Lipsius, who, in his *De Constantia* (Leiden, 1584), advocated avoidance in public affairs, and Thomas More, who though serving as ambassador, under-treasurer of the Exchequer, and Lord Chancellor, longed for the contemplative life throughout his career.

28 *Works* i.713–44/v.3–30. Cf. his treatment of the myth of 'Narcissus or self love' in *De Sapientia Veterum*, where the theme of the active as opposed to the contemplative life is taken up. Narcissus is treated as the paradigm example of the latter, for his concern is exclusively for the self rather than concern for the community, a view which Bacon associates with Aristotle's defence of the contemplative life. The fate of Narcissus – transfixed to the spot, oblivious of, and of no use to, anyone else – is an allegory of the fate of those who value contemplation above the active life. *Works* vi.632–3/705–6.

29 Among the more influential works that applied a humanist approach to war and military matters, and which were available in English in Bacon's time, are Justus Lipsius, *Sixte Books of Politickes or Civil Doctrine*, trans. William Jones (London, 1594), and Clement Edmundes, *Observations upon Cæsars Commentaries* (London, 1609).

ranged from very basic questions such as how to get the monarch's ear, to questions of propriety. Castiglione's *Il libro del cortegiano* (1528) was the most important and popular Renaissance treatise on education in manners and behaviour, setting out the duties of the courtier, particularly in his role as adviser to the monarch. The work was translated into English as *The Courtyer* (1561) by Sir Thomas Hoby, Bacon's uncle, and it became one of the most widely read books in England in the Elizabethan era.³⁰ Not only can we have little doubt that Bacon would have read this book – he will discuss it in some detail in his *Of Tribute*³¹ – but he was steeped in a culture, in England as much as in France, where such questions were integral to any thinking on advice on matters of state.³² The appropriate education, the appropriate attitude of mind, the appropriate behaviour and even demeanour, were the questions that informed thinking on these matters. Indeed, this is nowhere more marked than in *De Augmentis*, where Bacon turns the Socratic dictum 'know thyself' into a question of behaviour:

But it is not enough for a man only to know himself; for he should also consider the best way to present himself to advantage; to disclose and reveal himself; and lastly, to turn and shape himself according to the occasion. . . . It is no unimportant attribute of prudence in a man that he be able to set forth to advantage before others, with grace and skill, his virtues, fortunes, and merits (which may be done without arrogance or breeding disgust); and again, to cover artificially his weaknesses, defects, misfortunes, and disgraces; dwelling upon the former and turning them to the light, sliding from the latter or explaining them away by apt interpretations, and the like. (*De Aug.* VIII, chap. 2: *Works* i.779/v.66)

Turning from the contrast between *negotium* and *otium* to that between the philosopher and the poet, we are taken, I shall suggest, from the relatively settled question of the education and behaviour appropriate to the courtier, to the completely open question of the education and behaviour appropriate to the natural philosopher. In other words, it is this juxtaposition of the contrasts between the contemplative life and the

30 It was not necessarily read in Hoby's English translation (London, 1561), however: Bartholomew Clerke's Latin translation, commissioned on Queen Elizabeth's behalf, which appeared in 1571, had six English printings before 1612, compared with only four printings of Hoby. See J. W. Binns, 'Elizabeth I and the Universities', in John Henry and Sarah Hutton, eds., *New Perspectives on Renaissance Thought* (London, 1990), 244–52.

31 James Spedding, ed., *Bacon: A Conference of Pleasure* (London, 1870).

32 This is not to deny that there were criticisms of courtly behaviour, although these were more common in the Stuart era. An example is Nicholas Breton, *The Court and the Country* (London, 1618).

active or practical life, and philosophy and poetry, that shapes the conceptual space in which Bacon is able to think through the question of the practice of natural philosophy.

In asking whether it is the poet or the philosopher who is best placed to lay claim to an understanding of the world, it is important that we reflect on the nature of the question. We are not concerned with whether the doctrine is presented in meter or in prose, artistically or prosaically: Plato's own discussion, in Book 10 of the *Republic*, criticises the poet (and the artist more generally) for substituting images for reality, and for encouraging desire; yet Plato makes it clear that, in employing the dialogue form he is using a poetic device to raise philosophical issues.³³ Neither, however, are we concerned with some specific doctrinal content, since there will be as much variation in doctrine from philosopher to philosopher as there is from poet to poet. What is at issue is something quite different. The question that comes to the fore, especially in the subsequent development of the 'quarrel between philosophy and poetry', is that of the standing of philosophers and poets.

Philosophers – in antiquity, in the Middle Ages, and in the early-modern era – were able, with varying degrees of success, to construct images of themselves as paradigmatic bearers of moral, aesthetic, and intellectual responsibility. Whatever deep philosophical quarrels there might be among philosophers, it was important to establish that the philosophical view was not simply one kind of opinion among others. What was required was the construction of a philosophical persona capable of bearing and displaying this authority: an authority which was very different from that borne and displayed by theologians and statesmen, for example, whose claims on moral authority overlapped with, and perhaps competed with, those of philosophers. The question raised here is one about the relation between philosophy and the behaviour appropriate for the philosopher, or at least the philosophically educated: what kind of persona philosophy does or should shape or encourage. Bacon quotes with approval Cicero's commendation of Cato, for example, 'that he had applied himself to philosophy *non ita disputandi causa, sed ita vivendi* [not that he might dispute like a philosopher, but that he might live like one].'³⁴

Perhaps the most familiar example of this is Stoicism, for the 'Stoic' attitude – indifference to calamity and misfortune – is one that is still readily familiar. It receives an elegant formulation in Philo of Alexandria, at the end of the Hellenistic era, when he sets out how the persona of the philosopher or sage is to be formed:

33 On some of the complexities of what Plato is up to, see Stanley Rosen, *The Quarrel between Philosophy and Poetry* (New York, 1993), chap. 1.

34 *Adv. Learn.* II: *Works* iii.432.

Every person – whether Greek or Barbarian – who is in training for wisdom, leading a blameless, irreproachable life, chooses neither to commit injustice nor return it unto others, but to avoid the company of busybodies and hold in contempt the places where they spend their time – courts, councils, marketplaces, assemblies – in short, every kind of meeting or reunion of thoughtless people. As their goal is a life of peace and serenity, they contemplate nature and everything found within her. . . . Thus, filled with every excellence, they are accustomed no longer to take account of physical discomforts or exterior evils, and they train themselves to be indifferent to indifferent things; they are armed against both pleasures and desires, and in short, they always strive to keep themselves above passions.³⁵

There is a focus on moral questions here, but cognitive prescriptions were as often as not tied in to the general picture of the appropriate behaviour for the philosopher, either implicitly, as in the case of Hellenistic writers generally or occasionally explicitly, as in the case of Marcus Aurelius' advice:

Everywhere and at all times it is up to you to rejoice piously at what is occurring at the present moment, to conduct yourself with justice towards the people who are present here and now, and to apply rules of discernment to your present representations, so that nothing slips in that is not objective.³⁶

We must not forget that these were questions that were paramount throughout antiquity, and at least from Socrates onwards the philosopher took on or fostered a distinct persona and attitude, depending on the philosophical doctrine or school. For Plato, for example, the persona of the philosopher fitted him for kingship. For Diogenes the Cynic, on the other hand, it fitted him to the life of a beggar or a slave, and this was by no means something one merely fell into: It required an *askesis*, a pattern of living, which involved indifference to hardship and suffering (*apatheia*), self-sufficiency and a refusal to engage in the responsibilities of civil society (*autarkeia*), complete and blunt freedom of speech (*parrhesia*), and lack of shame in performing bodily functions (*anaideia*).³⁷

This fostering of a philosophical persona is particularly marked in the Hellenistic era, where *ataraxia*, peace of mind, was explicitly the aim of all the major schools, and where regulation of the passions played a major role for Epicureans and Stoics alike in attaining the state of mind, and corresponding behaviour, worthy of or appropriate to a member of their philosophical school. Indeed, as Hadot has remarked, it is love of wisdom, 'which is foreign to the world, that makes the philosopher a

35 Quoted in Pierre Hadot, *Philosophy as a Way of Life* (Oxford, 1995), 264.

36 Marcus Aurelius, *Meditations*, 7.54 (quoted in *ibid.*, 132).

37 See the discussion of Diogenes in chap. 13 of H. D. Rankin, *Sophists, Socrates and Cynics* (London, 1983).

stranger to it. So each school will elaborate its rational depiction of this state of perfection in the person of a sage, and each will make an effort to portray him.³⁸ This philosophical self-fashioning was pursued in a different way in the Christian era. This is nowhere clearer than in the disputes of the 1260s and 1270s arising from the attempts to introduce an autonomous philosophical system, that of Aristotle, into Christian thought. The Averroist Boethius of Dacia, one of the strongest advocates of philosophical 'self-affirmation', argued that it was easier for the philosopher to be virtuous than for anyone else, and that whoever does not live the life of a philosopher does not live rightly or virtuously.³⁹ Étienne Tempier, Bishop of Paris, with the backing of Pope John XXI, responded by condemning the propositions 'that no station in life is to be preferred to the study of philosophy' and 'philosophers alone are the wise men of the world' in the 1277 'Condemnation of 219 Propositions'.⁴⁰ No less striking is the idea of philosophical self-fashioning that pervaded the Renaissance thought, with Pico della Mirandola's eulogy on 'the dignity of man' being in fact an attempt to redefine the office of the philosopher as the paradigm sage, and to set out a programme for the attainment of this goal.⁴¹ Works like Montaigne's *Essais* and Burton's *Anatomy of Melancholy* show that the genre was alive and well in the early-modern era,

38 See Hadot, *Philosophy as a Way of Life*, 57. See also Paul Rabbow, *Seelenführung: Methodik der Exerzitien in der Antike* (Munich, 1954). The Epicureans, who did not recruit from within (e.g., from among the sons of their own members) and limited contact with the outside community, needed a particularly striking image of the Epicurean philosopher for recruitment purposes, and they commissioned many more busts of their founder than other schools. As Bernard Frischer notes in his *The Sculpted Word: Epicureanism and Philosophical Recruitment in Ancient Greece* (Berkeley, 1982), these busts portrayed Epicurus as at once 'the philosopher, father-figure, Asklepiian healer, Herculean culture-bringer, megalopsychos ("great-souled man"), and god' (p. xvii).

39 Boethius of Dacia, *On the Supreme Good*, ed. and trans. J. F. Wippel (Toronto, 1987), 32–5. See Georg Wieland, 'The Reception and Interpretation of Aristotle's *Ethics*', in Norman Kretzmann, Anthony Kenny, and Jan Pinborg, eds., *The Cambridge History of Later Medieval Philosophy* (Cambridge, 1982), 657–72.

40 Proposition 40: 'quod non est excellentior status quam vacare philosophiæ'; proposition 154: 'quod sapientes mundi sunt philosophi tantum'. See P. Mandonnet, *Siger de Brabant et l'averroïsme latin au XIII^e siècle, 2^{me} partie, textes inédits*, 2d ed. (Louvain, 1908), 175. In Mandonnet's schematic reordering these are the first and second propositions.

41 See William G. Craven, *Giovanni della Mirandola, Symbol of His Age* (Geneva, 1981), chap. 2. However, far from pursuing his programme in humanist terms, Craven points out (e.g., p. 44) that in the *Oratio* Pico is shaping the sage around philosophical Scholastic values rather than humanist ones.

although again the way in which it was pursued differed. It is just these differences that must concern us in the case of Bacon.

I have indicated that a crucial part of Bacon's project for the reform of natural philosophy was a reform of its practitioners. One ingredient in the latter reform was the elaboration of a new image of the natural philosopher, an image that conveyed the fact that the natural philosopher is no longer an individual seeker after the arcane mysteries of the natural world, employing an esoteric language and protecting his discoveries from others, but a public figure in the service of the public good, that is, the crown. What features must the practitioner of natural philosophy have? Here Bacon employs a model which centres around a contrast between the philosophical and the poetic persona. Philosophical self-fashioning had always turned on the understanding and regulation of the passions, and because of this they have a peculiar centrality, for they have not merely been one object of study among others for philosophers, but something which must be understood if one is to be 'philosophical' in the first place. Mastery of the passions was, in one form or another, not only a theme in philosophy but a distinctive feature of the philosophical persona from Socrates onwards, and Renaissance and early-modern philosophers pursue the theme of self-control with no less vigour than had the philosophers of antiquity. This, as we shall see, is the model, prominent in writers like Montaigne, around which Bacon wishes to shape his new practitioner of natural philosophy.⁴² It is a model inappropriate to the artisan, and it gives the new practitioner a dignity and standing that the collective nature of his work would not otherwise suggest.

The other half of the model, the persona of the poet, is equally important. On his return from Paris in 1578, Bacon became associated for a time with the 'Areopagus' group in London, a circle in which literary and political ideas were being hotly debated, ideas which figure in Sidney's *An Apology for Poetry*, his *Arcadia*, and in Spenser's *Faerie Queene*, which was being worked on at this time. It was Sidney above all who led the revival of poetry in 1580s, and the 'Areopagus', which met at Leicester House and was dedicated to the reformation of English poetry on Italian and classical principles, was arguing explicitly for the superiority of poetry over law, history, and philosophy. The law tries to make one good through *formidine pœna*, fear of punishment, rather than through *amor virtutis*, love of virtue, whereas poetry not only instills a love of virtue into its audience, but does so by moving their will, making

42 This is particularly evident in Bacon's posthumously published account of his scientific utopia, *New Atlantis* (1627), where self-respect, self-control, and internalised moral authority are central.

them want to be virtuous.⁴³ The historian, on the other hand, in dealing with particular events, 'must tell events whereof he can yield no cause',⁴⁴ whereas the poet can couple the particular instance with a universal consideration.⁴⁵ By contrast, philosophy does reveal causes, but it fails to move the soul to action, and so fails in the ultimate goal of knowledge.⁴⁶

The criticism of philosophy is worth pursuing a little, for it is here that Sidney and Bacon part company. The general claim was that philosophers can only follow nature, but nature since the Fall is corrupted, whereas the poet can create another nature which more closely mirrors eternal archetypes. This claim is founded on the superiority of the active, practical life over the contemplative one, and Sidney draws the consequences for moral thought, namely, that teaching the nature of virtue is not the same thing as, and indeed is no substitute for, moving people to practice virtue. Once the balance has moved from *otium* to *negotium*, the figure of the philosopher – which is still overlain with the idea of the disputatious Scholastic who achieves no real understanding, much less produces anything useful – becomes far less attractive. Sidney starts with the Platonically inspired idea, which we also find in writers like Richard Hooker, that although everyone is born with the 'light of reason' which enables one to distinguish truth from falsehood, the Fall has smothered this light: Nevertheless, some vestige of the light remains to the extent that everyone instinctively loves the highest virtue when they recognise it.⁴⁷ Sidney's argument is that the poet is better able to help them to this recognition than anyone else, for the poet has 'the Idea and fore-conceit' of things and can, by deploying fiction, produce these 'in

43 Sir Philip Sidney, *An Apology for Poetry*, ed. Geoffrey Shepherd (London, 1965), 106. On the Renaissance tradition of thinking of poetry in terms of instilling virtue, a tradition to which Sidney owes a great deal, see Brian Vickers, 'Rhetoric and Poetics', in Charles B. Schmitt, Quentin Skinner, and Eckhard Kessler, eds., *The Cambridge History of Renaissance Philosophy* (Cambridge, 1988), 715–45, at 735–40.

44 Sidney, *Apology for Poetry*, 110.

45 Ibid., 107.

46 Ibid., 112. Compare Bacon's assessment in *De Aug.* VII, chap. 1:

Moral philosophers have chosen for themselves a certain glittering and lustrous mass of matter, wherein they may principally glorify themselves for the point of their wit, or power of their eloquence; but those which are of the most use for practice, seeing that they cannot be so clothed with rhetorical ornaments, they have for the most part passed over. (*Works* i.715/v.4–5)

The idea that philosophers prefer useless learning to virtue goes back to Petrarch, and indeed is one of the mainstays of Petrarchian humanism.

47 See Maurice Evans's helpful introduction to his edition of Sidney's *Arcadia* (*The Countess of Pembroke's Arcadia* [Harmondsworth, 1977]), and Geoffrey Shepherd's introduction to his edition of Sidney's *An Apology for Poetry*. See also Kathy Eden, *Poetic and Legal Fiction in the Aristotelian Tradition* (Princeton, 1986).

such excellence as he hath imagined them.' Bacon provides an eloquent account of the claims of poesy, of the kind that Sidney offered, in the *Advancement of Learning*:

to give some shadow of satisfaction to the mind of man in those points wherein the nature of things doth deny it; the world being in proportion inferior to the soul; by reason whereof there is agreeable to the spirit of man a more ample greatness, a more exact goodness, and a more absolute variety, than can ever be found in the nature of things. Therefore, because the acts or events of true history have not that magnitude which satisfieth the mind of man, poesy feigneth acts and events greater and more heroical; because true history propoundeth the successes and issues of action not so agreeable to the merits of virtue and vice, therefore poesy feigns them more just in retribution, and more according to revealed providence; because true history representeth actions and events more ordinary and less interchanged, therefore poesy endureth them with more rareness, and more unexpected and alternative variations. So as it appeareth that poesy serveth and conferreth to magnanimity, morality, and to delectation. And therefore it was ever thought to have some participation of divineness, because it doth raise and erect the mind, by submitting the shews of things to the desires of the mind; whereas reason doth buckle and bow the mind unto the nature of things. (*Adv. Learn.* II: *Works* iii.343–4)

The claim is that the poet is able to present pictures which reveal the divine archetypes in a sensible form. Working through the imagination, he is able to awaken truths in the soul of the reader and uncover the innate forms of virtue. This is no theoretical issue for Sidney, who was very much a practical man: His biographer Fulke Greville writes of him as performing wonders 'even in the most ingenious of Mechanicall Arts'.⁴⁸ Above all, he is a man of action, closely associated with the religious reforms espoused by the Earl of Leicester,⁴⁹ and a champion of the Protestant cause in England and overseas, where he saw it as his duty to protect coreligionists against Spain and the papacy; indeed, he died in 1586 as a result of injuries received while behaving chivalrously / recklessly – depending on how one looks at it (he refused to wear armour when he saw that his opponents were not wearing any) – in an attack on a Spanish convoy.

⁴⁸ Fulke Greville, *The Life of the Renowned Sr Philip Sidney* (London, 1652), 20–1. See also Mordechai Feingold, *The Mathematicians' Apprenticeship: Science, Universities and Society in England, 1560–1640* (Cambridge, 1984), 125–7, on Sidney's mathematical interests while a student at Oxford, and after. Sidney studied chemistry / alchemy with Dee: See Francis R. Johnson, *Astronomical Thought in Renaissance England: A Study of English Scientific Writings from 1500 to 1645* (Baltimore, 1937), 137 n. 39.

⁴⁹ For details on the connections between *Arcadia* and the politics of the time, see Blair Worden, *The Sound of Virtue* (New Haven, 1996).

The choice, then, is in the first instance between the active or practical life and the contemplative life, where philosophers and to a lesser extent poets had traditionally fallen in the latter category, although neither poesy nor philosophy were strictly incompatible with the former. The explicit shift to the defence of the active or practical life, however, does place new requirements on these activities, for their practitioners now had to show that they were able to live up to the aims of the active or practical life. What Bacon effectively does is to transform philosophy into something that comes within the realm of *negotium*. This is completely at odds with the Platonic conception of philosophy, and makes it impossible to contrast poetry and philosophy in the Platonic way. Promoted through the rhetorical unity of *honestas* and *utilitas*, philosophy is presented as something good and useful, and thus as intrinsic to the active life.⁵⁰ Indeed, it starts to become a paradigmatic form of *negotium*, and thus it can usurp the claims made for poetry by writers such as Sidney.⁵¹ Moreover, Bacon achieves this by wholly traditional means: The novelty of his conclusion arises from his strategy of reworking some fundamental dichotomies common to all those operating within the rhetorical understanding of knowledge, not by questioning those dichotomies.

Nevertheless, to state matters thus is to highlight contrasts somewhat more sharply than we find them in Bacon or his contemporaries. In particular, we should not draw the contrast between poesy and philosophy too finely, for certain traditional philosophical themes, such as the importance of curbing the passions, reappear in the defenders of poesy in as determined a way as they ever did in philosophy. Moreover, even if some kind of distinction can be maintained at the abstract level, when we come to actual cases the divide between philosophy and poesy is not always so clear. Montaigne's *Essais*, Bacon's *Essayes*, and Burton's *Anatomy of Melancholy* are cases in point: They are explicitly both literary and philosophical works. The situation is complicated by the fact that just how one goes about writing philosophical works seems to become problematic (outside the Scholastic tradition) in the early decades of the sev-

50 In Book 1 of the *Advancement of Learning*, Bacon writes:

But this is that which will indeed dignify and exalt knowledge, if contemplation and action may be more nearly and straitly conjoined and united together than they have been; a conjunction like unto that of the two highest planets, Saturn the planet of rest and contemplation, and Jupiter the planet of civil society and action. (*Works* iii.294)

This looks like a reconciliation of *negotium* and *otium*, and, in context, such a reconciliation is a way of making the same point, that is, of undermining the purely contemplative view of philosophy.

51 Compare Bacon's remark in the *Cogitationes de Scientia Humana* (c. 1603):

Natural history which rests on insufficient research and insufficient testing gives rise to two faults and, as it were, two diseases or corruptions of theory. The first results in sophistry, the second in poetry. (*Works* iii.187)

enteenth century. Robert Fludd's writings, to take an extreme example, depend as much, if not more, on pictorial representation as on verbal description. In his *Utriusque Cosmi*, the first volume of which appeared in 1617, verbal description is treated as being insufficient if we are to capture the deep, hidden relations between the world of sensation and the intelligible reality that underlies it, and pictorial representation is able to capture such mysteries as the Trinity in a way that verbal description is not. In Fludd's view, the depth of the mysteries underlying these themes makes verbal reasoning inadequate: Pictorial representation is better able to express the complexities and different levels of what is involved. But this problem is confined neither to England, nor to marginal figures such as Fludd.⁵² In France, while Gassendi is floundering under the traditional textbook form, unable to get his thoughts across, as they pile up in the *Syntagma* with no obviously appropriate form of expression,⁵³ Descartes is experimenting with just about every available genre short of the epic poem – essay (*Discourse on Method*), dialogue (*Search for Truth*), textbook (*Principles of Philosophy*), and what might be described as devotional literature (*Meditations*)⁵⁴ – and in 1645 Hobbes will revel in the fact that his paradoxical mode of presentation confounds his critics.⁵⁵ These genres have literary precedents as much as philosophical ones.

52 What is at issue here is rather different from, although in some respects a precursor to, the choice between what might be termed humanist and modernist modes, with which Hobbes struggled: see Quentin Skinner, *Reason and Rhetoric in the Philosophy of Hobbes* (Cambridge, 1996).

53 Petrus Gassendi, *Opera Omnia*, 6 vols. (Lyon, 1658), vols. i, ii.

54 It is sometimes thought that Descartes's *Meditations* and *Principles* are loosely based on a geometrical method of presentation (starting from axioms and deriving theorems from these). I have argued elsewhere that this is an egregious misunderstanding of Descartes's project, and suggested some of the precedents: See my 'The Sources of Descartes' Procedure of Deductive Demonstration in Metaphysics and Natural Philosophy', in John Cottingham, ed., *Reason, Will, and Sensation* (Oxford, 1994), 47–60, now reprinted in my *The Genealogy of Knowledge* (Aldershot, 1997), 153–66. See also Dennis Sepper, 'The Texture of Thought: Why Descartes' *Meditationes* Is Meditational and Why It Matters', in Stephen Gaukroger, John Schuster, and John Sutton, eds., *Descartes' Natural Philosophy* (London, 2000), 736–50.

55 'My odde opinions are bayted. but I am contented wth it, as beleeuing I haue still the better, when a new man is sett vpon me; that knowes not my paradoxes, but is full of his owne doctrine, there is something in the disputation not vnpleasant. He thinkes he has driuen me vpon an absurdity when t'^s upon some other of my tenets and so from one to another, till he wonder and exclaime and at last finds I am of the Antipodes to y^e schooles.' Hobbes to Waller, 8 August 1645: Hobbes, *The Correspondence*, ed. Noel Malcolm, 2 vols. (Oxford, 1994), i.124. On the literary genre of paradoxes, see R. L. Colie, *Paradoxia Epidemica: The Renaissance Tradition of Paradox* (Princeton, 1966).

In short, while there is a sense in which, having decided in favour of the practical or active life, one then pursues questions of knowledge and virtue in the context of various models of practically orientated intellectual activity, in which philosophical and poetic models (as opposed to mathematical or theological models, for example) predominated – and, so far as I can tell, in the case of England in the 1580s and 1590s, pretty well exhausted what was available – it is not simply a question of making a clear-cut distinction between a philosophical or a poetic/literary model. Despite the confident statements of writers such as Sidney, it is in fact difficult to provide any comprehensive account of these intellectual issues without recourse to both kinds of model, which mesh with one another at various points.

Even given this, however, we must still recognise that what the models provide is a conceptual space in which the questions can be raised: They do not necessarily motivate these questions. Identifying the space in which such questions are likely to be treated is crucial, but it is not going to be of help if one wants to know why Bacon takes up the question of the reform of natural philosophy in the first place. It is true that there is a traditional philosophical concern with natural philosophy, and this is certainly of central importance in understanding Bacon's interest in it, but he does not simply take over the traditional philosophical treatment of such issues: His approach is quite tangential to traditional concerns, whether those of Scholastic philosophers or of the Renaissance naturalists. He is motivated by two kinds of issue. The first is the fact that if natural philosophy is to be of use to the state, if it is to add to the productive capacity of the nation, then it must be reformed from an esoteric discipline into a public one. Bacon comes to believe that the administration of natural-philosophical endeavours for the public good should be as much an object of concern to the statesman as the administration of justice and trade. Moreover, and this is the second point, because of a number of parallels between the malaise of natural philosophy in England and the inappropriate way in which the law and public administration are pursued in England, and because the remedies that Bacon works out for the latter have a bearing on questions of evidence and demonstration which are at the core of the problem in the former, reforms – or at least projected reforms – in one such area of public administration deliver valuable lessons for another.

The reform of law

In the period from 1592 to 1602, Bacon's humanistically conceived concern to secure the well-being of the state, and to increase its benefits, effectively split into two: the reform of law and the reform of natural philosophy. For most of this period his concerns, driven very much by

his political position, were predominantly in the area of the former; but in about 1602 we can detect the beginning of an important change in emphasis in his interests, with natural philosophy becoming increasingly significant – although someone whose career will take him through the positions of Solicitor-General (1607), Attorney-General (1613), Lord Keeper (1617), and finally Lord Chancellor (1618) would naturally retain an active interest in law and legal reform, as Bacon did.

Since our interest is in the ways in which Bacon's concern with legal questions bears upon his programme in natural philosophy, it is important we begin by asking what the connection between law and natural philosophy could be. To understand this connection, we need to introduce a third ingredient: rhetoric, conceived as the general discipline of the rules of discovery and presentation driving classical humanism. We need to understand the relation between law, natural philosophy, and the general kinds of claim made about discovery and the organisation of inquiry in the theories of rhetoric that make up the core of classical humanist learning. Without this, I suggest, law and natural philosophy simply do not have a relation beyond that of analogy – and Bacon clearly intends far more than that. What underlies his reform of natural philosophy is a distinctive stance within traditional humanism. The connection between natural philosophy and the law is mediated by rhetoric, for rhetoric contains the art of discovery that underlies both law and natural philosophy; but natural philosophy and law are not on a par in this respect, for the law, if reformed, is a paradigm manifestation of rhetoric. Nothing is better placed than the law, if suitably reformed along humanist lines, to act as a model for all inquiry. The law is a model for natural philosophy because of its intimate connection with rhetoric.

In outline, three transformations are required. First, humanism itself is transformed; the aims of just what is involved in the active, practical life of wisdom – *negotium* – are redefined and clarified, and, as we have seen, Sidney's defence of poetry at the expense of law, history, and philosophy is overturned by Bacon, who defends the primacy of philosophy, in the form of a new practically orientated natural philosophy. Second, the law itself, particularly legal procedure and the source of legal authority, is transformed, so that it coheres with the aims of the reformulated humanism and can act as an exemplification of the values of the humanist. In this way, it can be made to bear the weight of the wholly general claims that humanist theories of rhetoric made about discovery and presentation. Third, this model, once made wholly general, is applied to the case which Bacon's recasting of the values of humanism has made the most important one, namely natural philosophy.

We have already seen that there is direct relation between the first and the third of these: Bacon's recasting the figure of the natural philosopher in line with the claims of *negotium* makes the natural philosopher, rather

than the poet or the moral philosopher, the paradigmatic bearer of humanist wisdom and learning. If there is a direct relation, it will be asked, why is law needed as an intermediary? The need derives from the fact that the way in which the natural philosopher must be formed or shaped is of necessity going to be very different from the way in which the poet or moral philosopher was shaped. The question is: What kind of things does one have to do – in what kind of behaviour does one have to engage – to become a natural philosopher in the sense of a paradigmatic bearer of *negotium*? Clearly nothing in the traditional ways of pursuing natural-philosophical inquiry, whether in the work of the Scholastics or in that of the alchemists, is appropriate. Some other model is required. At the most general level, as we have seen, questions of the appropriate way to proceed in a discipline were the province of rhetoric and, as we have also seen, much of rhetoric was directed towards legal reasoning, legal argument, and legal investigation. The law was really as close as one got to a model for inquiry and argument, and history and philology, for example, took it as a precedent in various ways.⁵⁶ It was therefore the natural place to which to return, if one was starting again from scratch, as was Bacon; and his general understanding of the aims and procedures of humanism led him to ask what forms of legal inquiry, argument, and organisation meet these aims and procedures, to envisage what a legal system reformed along fundamental lines might look like, and what practically might be done to remedy defects in the current practice of law.

Before we look at Bacon's proposals for the reform of law, however, we should look at just what is attractive about legal procedure as a general model for inquiry. Bearing in mind the broad rhetorical context of discovery and demonstration, legal procedure in Elizabethan England can be contrasted with philological and Scholastic forms of disputation. As we have seen, Bacon believes that purely empirical procedures, such as those employed by alchemists, are arbitrary and lack any real method, and it is only those that purport to follow a general procedure that are of interest in this context. Yet the philological and Scholastic methods are purely textual. In the former case, there may be quite a sophisticated understanding of evidence – for example, with regard to establishing authenticity – but this would only consist in comparing one piece of textual evidence with another.⁵⁷ In the latter case, there may be considerable subtlety of argument – for instance, in reconciling Aristotelian

⁵⁶ See Julian H. Franklin, *Jean Bodin and the Sixteenth Century Revolution in the Methodology of Law and History* (New York, 1963).

⁵⁷ For an example of the kind of thing involved, at the highest level of sophistication, in philological methods, see the discussion of Scaliger in Anthony Grafton, *Joseph Scaliger, a Study in the History of Classical Scholarship*, 2 vols. (Oxford, 1983–93).

metaphysics with revealed religion – but little by way of empirical inquiry.⁵⁸ Moreover, as we saw in Chapter 1, Bacon rejects the idea that mathematical reasoning could tell us anything about reality.

Legal reasoning aims at discovering the truth and has a very practical imperative to do so. The assessment of evidence plays a crucial role in coming to a judgement, and this evidence must go beyond the textual. Moreover, the procedure by which one arrives at a judgement must be open to scrutiny and, ideally, mechanical, in the sense that any qualified person assessing the same case on the same evidence would come to the same judgement.⁵⁹

Following Julian Martin, this procedure can usefully be broken into stages.⁶⁰ The first stage hinges on the question of the reliability of testimony, and the problem is that of discovering under what conditions testimony can be deemed to be reliable. Testimony was something offered by witnesses, who swore under oath to tell what they knew or believed, in answer to a list of questions drawn up by the plaintiff or the defendant. In the case of Chancery, the questions asked were the same, and asked in the same order, for each witness, and they were scrutinised, with the Master of Chancery, to whom they were submitted, having the power to exclude some remarks, and to order a viva voce examination of the witness to supplement answers. In the case of the Star Chamber, the defendant as well as the witnesses was examined under oath, and when the case involved questions of treason, the suspect could be examined on his or her knowledge of other conspirators or other conspiracy. Generally, testimony did not in itself constitute evidence: It had to be sifted, analysed, and assessed before it could serve to establish the facts of a case. It was testimony which had been analysed and assessed that was used to present the facts of the case, and it was treated as compelling evidence, even if the witness, once freed from the rigours of the investigatory process, subsequently tried to retract particular parts of the testimony. To be able to analyse and assess various testimonies so that they could have such a standing, various tests for reliability had to be

58 The extensive discussions of cosmology in the Middle Ages might be taken as an example of the kind of work involved. See Edward Grant, *Planets, Stars and Orbs: The Medieval Cosmos, 1200–1687* (Cambridge, 1994), especially the catalogue of questions that were disputed, given on pp. 681–741.

59 Perhaps in a more literal sense as well, for in the Preface to *Novum Organum*, he will tell us that ‘There remains but one course for the recovery of a sound and healthy condition, namely, that the entire work of understanding be commenced afresh, and the mind itself be from the very outset not left to take its own course, but guided at every step; and the business be done as if by machinery’ (*Works* i.152/iv.40).

60 In my discussion of English law and Bacon’s attempts to reform it, I follow the very helpful account in Martin, *Francis Bacon*, chaps. 4 and 5.

met. Testimonies often conflicted, for example, so a witness's testimony would be judged against that of others, and perhaps questioned on grounds of internal consistency or plausibility. There were also various degrees of reliability that could be established in general terms. The testimony of someone with first-hand knowledge of an event was to be preferred to that of someone with only second-hand knowledge, for obvious reasons. The testimony of a gentleman was superior to that of a servant, presumably because gentlemen were independent agents in a way that those whose livelihood was completely dependent upon others were not, and so their word meant more, as they were subject to no pressures from outside.

Even testimony so analysed and assessed could not decide the issue, however; it was merely a way of presenting the facts. The next stage was the establishment of what exactly happened: This involved using testimony to prove that a particular event or act had occurred. Questions of assessment of degrees of probability and plausibility arose here, and this was an area in which traditional texts in rhetoric, such as Cicero, the *Rhetorica ad herennium*, and Quintilian – but not those in philosophy, which were preoccupied with demonstrative reasoning – were well equipped to offer instruction. Sometimes, however, the dispute was not about the facts but about whether what was done was an infringement of the law, which turned on the question of which laws were relevant in this particular case and what interpretation should be placed upon them. Again, training in that discipline which concerned itself with the 'discovery of arguments', namely the topics, which by this stage was exclusively associated with rhetoric, would have proved invaluable. Finally, once these questions had been resolved, one could arrive at a judgement on the case.

There are three important stages in this procedure from the point of view of the application of a legal model to natural philosophy: the reliability of testimony, what should be concluded from particular testimonies, and how one decided the relevance of particular laws to the case. The first two are obviously relevant to natural philosophy, and a good deal of Bacon's project in natural philosophy – especially works like *Sylva Sylvarum*, where a mass of material from very different sources is produced – hinges on questions of the reliability of testimony and how one can draw general conclusions from it; but the third point is also of relevance, for it is to this question that Bacon's reforms are primarily directed. The substance of the third area is set out succinctly by Martin, who points out that, in the sixteenth century, 'the common law was regarded as encompassing more than the statutes, royal proclamations and the older judicial decisions; it was believed to be a huge body of law, including much which was unwritten.' This made the project of 'discovery' of the law a crucial one. It was a shared premise that the law was

structured in accord with reason, 'and because of this structure, when the known laws did not give a clear indication of infringements, lawyers would appeal to what they took to be the implicit message of the common law.'⁶¹ It was assumed that the law encompassed every eventuality, and that it was a question of finding one's way through its rational structure. There were two issues here: first, how best to expose the rational structure of the law, and second, in part because there would inevitably be conflicting claims to having exposed that essential structure, the question of the ultimate authority under which this process was pursued.

Bacon was on a government committee for the reform of law in December 1588,⁶² but although he clearly gave the question of reform a great deal of consideration throughout his career, the only systematic writing on the law is his *Maxims of the Law*, which was probably drafted between 1593 and the end of 1596.⁶³ His proposed reform of law involves recommendations for its systematisation, but also for its ultimate authority. In the first place, he wants to reform legal procedure as part of a humanistically inspired programme of providing a proper foundation for investigative activity. Second, and perhaps correlatively, this programme requires a central authority, some ultimate arbiter or point of scrutiny, by which ingredients in the programme are to be judged. In the first case, this requires new ways of collecting and collating records; in the second case, it requires the institution of a central authority. Both these ingredients are important not just in the reform of law itself but in its applicability as a general model of inquiry. The collecting and collating of records, for example, is something that is crucial in both law and medicine. Criticising current practices in medicine, Bacon laments

the discontinuance of the ancient and serious diligence of Hippocrates, which used to set down a narrative of the special cases of his patients, and how they proceeded, and how they were judged by recovery or death. Therefore having an example proper in the father of the art, I shall not need to allege an example foreign, of the wisdom of lawyers, who are careful to report new cases and decisions for the direction of future judgements. (*Adv. Learn.* II: *Works* iii.373-4)

The basic form of systematic presentation of the law in the Tudor and Elizabethan periods was the 'year books', reasonably comprehensive volumes of reports on law cases which represented a 'common erudi-

⁶¹ Ibid., 79.

⁶² Jonathan Marwil, *The Trials of Counsel: Francis Bacon in 1621* (Detroit, 1976), 65.

⁶³ The work was not published in Bacon's lifetime, and the only published version of the text is in the *Works* vii.307-87. A better edition of the text, based on the manuscripts in the Cambridge University Library, is being prepared by Julian Martin for *BW*.

tion' of the legal profession. However, in the late Elizabethan–early Jacobean period, we find the beginnings of a general demand not just for the judgements but for the reasoning behind those judgements, and legal precedents take on a crucial role in legal argument. As Martin notes, 'this new way of arguing from old cases to the present one considerably reinforced the common assumptions about the law being a substantial entity, rational in its hidden structure.' Emphasising the strong sense in which there is a significant role for discovery in legal thinking, he points out that 'it required that hidden truths of the law be uncovered by the diligence of men learned in law . . . , and it assumed that these insights actually had governed the decisions of judges.'⁶⁴ The importance of this lies in the fact that the underlying principles of common law were treated on a par with the way in which philosophers spoke of fundamental principles, and Martin provides an explicit quote from Edward Coke, the most eminent lawyer of the day, on this question:

It appeareth, that *jurisprudentia legis communis Angliae est scientia socialis* . . . sociable, in that it agreeth with the principles and rules of other excellent sciences, divine and human.⁶⁵

I have drawn attention to the ways in which rhetoric, to the extent that it made discovery its own, acted as a foundation for the law in this respect, but we can now begin to appreciate another dimension of law, in which its ultimate aim is to uncover fundamental truths about the proper regulation of society, fundamental truths on a par with those of moral philosophy, metaphysics, and natural philosophy. All attempt to discover some underlying structure of reality and, if pursued within a humanist context (as opposed to a Scholastic one, for example), all will use the essentially Aristotelian notions of discovery as presented in humanist writers from Cicero to Melancthon. Indeed, it is only within a humanist context that the standing of law could be put on a par with these other disciplines. The contrast between humanist practice and Scholastic practice is not sharp in every respect, if only because no one after the first couple of decades of the sixteenth century, so far as I can tell, would have received an education in Scholastic philosophy without first going through the humanist curriculum thoroughly. However, the reconciliation of metaphysics and Christian teaching which largely pre-occupied Scholastic thinkers imposed a very different sense of what was fundamental,⁶⁶ one with no place in it for the notion that the law might

⁶⁴ Martin, *Francis Bacon*, 95–6.

⁶⁵ *Ibid.*, 96.

⁶⁶ The concerns of Scholastic metaphysics in the Renaissance are explored in a masterly way in Charles Lohr, 'Metaphysics', in Schmitt et al., eds., *The Cambridge History of Renaissance Philosophy* (Cambridge, 1988), 537–638.

be construed in such fundamental terms. Again, we must not lose sight of the context that enables the law to be construed as *scientia* in the first place, and consequently as something that might act as a model for other areas of inquiry.

Bacon clearly did not believe that the law as it stood was adequate, but his proposed reforms were aimed at giving it a rational structure and authority which might well provide it with such a paradigmatic status. He set out his proposed reforms of English common law in the *Maxims of Law*. His aim, he tells the queen in its 'Epistle Dedicatory', is

to enter into a general amendment of the state of your laws, and to reduce them to more brevity and certainty; that the great hollowness and unsafety in assurances of lands and goods may be strengthened, the snaring penalties that lie upon many subjects removed; the execution of many profitable laws revived; the judge better directed in his sentence; the counsellor better warranted in his counsel; the student eased in his reading; the contentious suitor that seeketh but vexation disarmed; and the honest suitor that seeketh but to obtain his right relieved. Which purpose and intention, as it did strike me with great admiration when I heard it, so it must be acknowledged to be one of the most chosen works, of highest merit and beneficence towards the subject, that ever entered into the mind of any king: greater than we can imagine; because the imperfections and dangers of the laws are covered under the clemency and excellent temper of your majesty's government. (*Works* vii.316)

Our concern here is less with the details of Bacon's reforms than with what drives them. His exemplar or prototype is the emperor Justinian, 'who, having peace in the heart of his empire . . . chose it for a monument and honour of his government, to revisit the Roman laws, and to reduce them from infinite volumes and much repugnancy into one competent and uniform corps of law.'⁶⁷ The parallels Bacon draws between English sovereigns and Justinian make it very clear that he sees the ultimate responsibility for the reform of the law to lie, not with lawyers and judges, but with the sovereign.

Bacon's aim is to 'visit and strengthen the roots and foundation of the science itself' and his systematic reform rests on identifying and setting out the basic principles which he considers be to dispersed throughout the common law:

67 'Epistle Dedicatory' to *Maxims of the Law*: *Works* vii.314. Lisa Jardine and Alan Stewart point out that Bacon had been sent to France in 1576 'primarily to bolster the somewhat parochial training in English common law he might be expected to gain at Gray's Inn with an understanding of Roman law, as practised in France' (*Hos-tage to Fortune*, 39), and point out that his attempted codification of English law was on a French model that he may well have learned from the French lawyer into whose care he had been placed in 1578 (*ibid.*, 61).

Having therefore from the beginning come to the study of the laws of this realm with a mind and desire no less . . . that the same laws should be better by my industry, than that myself should be better by the knowledge of them; I do not find that, by mine own travel, without the help of authority, I can in any kind confer so profitable an addition unto that science, as by collecting the rules and grounds dispersed throughout the body of the same laws: for hereby no small light will be given, in new cases and such wherein there is no direct authority, to sound into the true conceit of law by depth of reason; in cases wherein the authorities do square and vary, to confirm the law, and to make it received one way; and in cases wherein the law is cleared by authority, yet nevertheless to see more profoundly into the reason of such judgments and ruled cases, and thereby to make more use of them for the decision of other cases more doubtful. (*Works* vii.319)

The ultimate or most fundamental laws, Bacon makes clear, are 'the conclusions of reason' on which 'particular and positive learnings of laws' must ultimately rest.⁶⁸ The means by which this is to be achieved are of especial interest. Bacon is not proposing that he personally, or indeed any one person, sift through all the laws and come up with suggestions for reform. Nor is he proposing that this would be a one-off venture, which would establish a true basis for the law in the one fell swoop. The project is necessarily both collective and continuous; it would involve committees of trained lawyers sifting through law reports, ancient records, and current statutes; and this process would necessarily be continuous, the committees building their conclusions back into their reformed law reports, statute books, and so on.⁶⁹ The ultimate authority here is the sovereign, not lawyers or the people. Bacon's reforms would give judges less discretion in individual cases, and his aim was clearly to curtail the independence of judges. Moreover, not only does he, scorning Parliament's claims, clearly consider the legislative power of the state to reside in the sovereign, but his 'Proclamation for Jurors'⁷⁰ – issued in 1607, the year Bacon became Solicitor-General – seeks to exercise sovereign control over the selection of jurors, instructing sheriffs and others to make efforts to appoint more 'gentlemen of quality' to juries. This indicates that the native intuitions of the population about the kinds of matters brought before the courts do not count as much for him as they would for someone more firmly committed to the common-law tradition. Expertise and authority are what he seeks, even within the confines of a common-law tradition, and Martin is surely right in pointing out that Bacon, in his attempts 'to emasculate the common law as practised by his contemporaries and to subordinate it to the profession

68 *Works* vii.320.

69 See the treatment of these questions in Martin, *Francis Bacon*, chap. 5.

70 *Works* x.389–92.

to its royal master', is really after, although he cannot admit to it, a form of civil law, in which trial procedure, court process, and the powers of the ruler would be very different.⁷¹

There are parallels with Bacon's attempts to reorganise natural philosophy here, and in *Valerius Terminus* (1603), in an attempt to remedy the isolation of particular parts of knowledge from 'the root and stock of universal knowledge', he advocates a centralized system for the administration of knowledge like that used by the king of Spain to administer his colonies, 'who though he hath particular councils for several countries and affairs, yet hath one council of State or last resort, that receiveth the advertisements and certificates from all the rest.'⁷² The parallel with the centralized reform of law could not be closer. Many other parallels are highlighted in *De Interpretatione Naturae*, a brief incomplete work which dates from around 1603, which deals with the reform of natural philosophy. A point Bacon stresses is the cumulative long-term nature of any viable project in natural philosophy.⁷³ Although the 'dignity of knowledge' is maintained by 'works of utility and power', in the early stages of the investigation of nature one should avoid 'all application to works.' Bacon identifies premature application as the most significant cause of the failure of natural-philosophical theories. In answer to the charge that he is unable not only to produce any 'actual works', but cannot even offer definite promises of what useful applications will result from his proposed investigations, he answers that 'the knowledge that we now possess does not even teach us what to wish for.' To the charge that he has not proposed examining precedents, he simply states that there are none for the kind of project he has in mind.

Nevertheless, we need to be cautious about simply translating from law to natural philosophy. Although both the law and natural philosophy must be reformed if they are to serve their purposes properly, and although the idea of the premature application of reformed theories clearly can hold in law as much as in natural philosophy, the analogy is not exact; for Bacon does not deny that the law of the day needs to be applied until it can be reformed properly, whereas his estimate of the natural philosophy of the day is much lower. In the case of law, there is nothing to indicate that Bacon would have considered that the knowledge that we now possess does not even teach us what to wish for. On the question of precedents, Bacon certainly does not think we can or should proceed in the reform of law without considering precedents: Much of the reform in fact hinges on identifying and clarifying precedents. In short, there are indeed parallels, and the project for the reform

⁷¹ Martin, *Francis Bacon*, 127–9.

⁷² *Val. Term.*: Works iii.231.

⁷³ *De Interp. Nat.*: Works iii.519–20/x.86–7.

of law does indeed act as some kind of model for the reform of natural philosophy – and can do so, as I have indicated, because of their shared basis in the humanist understanding of inquiry. Nonetheless, we cannot simply translate from the one to the other: There are all kinds of contingent and local factors which prevent a straightforward application of the one to the other. There is also a very striking difference, however, one that marks out natural philosophy as an especially problematic kind of enterprise. Natural philosophy, as Bacon envisages it, needs to be legitimated as an area of activity that it is proper and fruitful to pursue. It is to this question that we now turn.

The legitimization of natural philosophy

Zealotry and the well-ordered state

In the late 1580s, Bacon began to be concerned about what he saw as ill-considered criticisms of traditional learning, and the attempt by radical Puritans to set themselves up as arbiters of knowledge. His hostility to this movement is explicit, and there are two strands in his criticisms of it. First, there is an unyielding commitment to the authority of the sovereign. Bacon tells us approvingly in *An Advertisement touching the Controversies of the Church of England* of 1589 that 'it is a precept of Salomon, that the rulers be not reproached; no, not in thought: but that we draw our very conceit into a modest interpretation of their doings.'¹ This is very much in line with traditional Tudor thinking, which was quite sensitive to potentially disruptive forces in society and aimed to contain the various forces in society by subordinating them to the absolute authority of the sovereign.² Although there has been a tendency to stress this ingredient in Bacon's criticisms, as if it in itself sufficed to explain them,³

1 *Works*, viii.81. The *Advertisement* was written as a response to a pseudonymous attack on the bishops by a 'Martin Marprelate', Bacon's aim being to support the authority of the bishops, although his account is balanced, and is not uncritical of the autocratic measures of the bishops.

2 Generally, see Whitney R. D. Jones, *The Tudor Commonwealth, 1529-1559* (London, 1970); J. H. Hexter, *Reappraisals in History: New Views in History and Society in Early Modern Europe* (Chicago, 1979); and John E. Leary, Jr., *Francis Bacon and the Politics of Science* (Ames, Iowa, 1994).

3 Leary, *Francis Bacon and the Politics of Science*, does this, and to some extent so does Julian Martin, *Francis Bacon, the State, and the Reform of Natural Philosophy* (Cambridge, 1992). Martin sees the matter in terms of elitism (p. 41), but this seems to me an inappropriately anachronistic notion which draws attention away from the fact that humanists had very specific views about the nature of learning and governance, and very specific criticisms of the Puritan challenge. The issue is not the de facto ignorance of the Puritans but the fact that they make claims to be heard that are based on something other than learning.

I want to suggest that it is not enough, at least at anything other than a general perfunctory level. It is a second ingredient in Bacon's criticisms which I believe should bear the explanatory weight: This is the fact that his criticisms are very specifically those of a Renaissance humanist.

In Chapter 2, we saw that the two principles to which both Italian and northern humanists were committed were the importance of sound learning for sound government, and the responsibilities of humanists to provide such sound learning in the practical context of government. The first feature was conspicuously absent from the radicalised Puritanism of the late 1580s, and Bacon's target in a number of writings dating from 1589/90 is the substitution of zealotry for learning.⁴ This he makes clear in his *Advertisement*: Most zealots, we are told, are 'men of young years and superficial understanding, carried away with partial respect of persons', and their contentions 'either violate truth, sobriety, or peace',⁵ which are, as we have seen, the chief aims of the humanists' conception of a well-ordered state. They 'leap from ignorance to a prejudicate opinion, and never take a sound judgement in their way.'⁶ They are, in short, incapable of assessing and making sound judgements on the cases they consider; yet they not only come to conclusions on such cases, but do not consider their lack of learning a handicap. It is for these reasons that Bacon insists that 'the people is no meet judge nor arbitrator, but rather the quiet, moderate, and private assemblies of the learned.'⁷

The threat posed was both broad and complex, however, and Bacon was not alone in perceiving the danger. In the preface to *De Magnete*, Gilbert complains of the 'Ocean of Books' published in his time,

through which very foolish productions the world and unreasoning men are intoxicated, and puffed up, rave and create literary broils, and while professing to be philosophers, physicians, mathematicians, and astrologers, neglect and despise men of learning.⁸

It was not just that there was a movement afoot which had eschewed learning in favour of some special form of insight to which Puritans had

4 See the excellent discussion in Martin, *Francis Bacon*, 42ff.

5 *Advertisement: Works* viii.82.

6 *Works* viii.82–3.

7 *Works* viii.94.

8 William Gilbert, *On the Magnet*, trans. Silvanus P. Thompson (New York, 1958), Preface, n.p. Stephen Pumfrey, 'William Gilbert's Magnetic Philosophy, 1580–1684: The Creation and Dissolution of a Discipline', Ph.D. thesis (Warburg Institute, London, 1987), argues that one of the main aims of publishing *De Magnete* was to reclaim magnetism for natural philosophy from unlicensed magical writers (pp. 14–73). More generally on the threat of printing in England at this time, see Adrian Johns, *The Nature of the Book* (Chicago, 1998), esp. chap. 2.

claimed access. There was also an extensive undergrowth of literature, in the form of self-help and self-improvement books – some of it based on the *problemata* model of frequently asked questions with answers, following prototypes traditionally ascribed to Aristotle, Alexander of Aphrodisias, and Plutarch, and some of it apparently *sui generis* – which was beginning to replace traditional learning. This literature was strongly associated with the Puritan movement in England, and the problem was that it contained much of practical value mixed in with much that was unremarkable and much rubbish. This posed a challenge for a humanist conception of practical knowledge. Unlike the Aristotelian tradition, to which the humanist was actually much closer (the rhetorical model had its origins in Aristotelian psychology and owed a great deal to Aristotelian ethics), it actually produced material of some worth and use, especially in the area of natural philosophy, but in a completely unsystematic way. It was this lack of system that permeated its production that was responsible for the resultant indiscriminate mixture of wheat and chaff, a mixture that its proponents were unable to sort out for themselves, and from which they were as a consequence unable to learn any lessons. When we consider the matter a little more closely, the real challenge, as far as natural philosophy was concerned, would then seem to have been not how to rebut the Puritan threat, but rather how to extract what was valuable in it, and how to create the environment in which it could be nurtured so as to maximise its yield.

By 1592, Bacon's targets have broadened considerably. His concern is now with the two predominant scientific traditions in sixteenth-century England: the Scholastic tradition, described in terms broad enough to include not only Aristotelians but Ramists as well, and the tradition of alchemy – or, more broadly, natural magic – which would undoubtedly have included figures such as Edward Kelley and John Dee. Bacon wrote to Lord Burghley in that year:

I have as vast contemplative ends, as I have moderate civil ends; for I have taken all knowledge to be my province; and if I could purge it of two sorts of rovers, whereof the one with frivolous disputations, confutations, and verbosities, and the other with blind experiments and auricular traditions and impostures, hath committed so many spoils, I hope I should bring in industrious observations, grounded conclusions, and profitable inventions and discoveries; the best state of that province. (*Works* viii.109)

The theme is pursued in the speech 'In Praise of Knowledge', which was given later in the same year at a masque devised by Essex for the queen.⁹ The speech is very much in the tradition of 'mirrors for princes', a genre

9 The speech was preceded by one on magnanimity, and one on love, and was followed by an oration in praise of the queen.

devoted to the moral virtues of the ruler. This genre, which flourished in sixteenth-century continental Europe, was actually rather rare in England,¹⁰ although models were available in Elyot's *The Boke named Governour* (1531) and Hoby's translation of Castiglione (1561). Bacon elaborates on the traditional themes of fortitude and love, but when he comes to the third such theme, knowledge, he does not deal, as was traditional, with the questions of virtue and self-knowledge, but rather with natural knowledge.¹¹ The new theme is approached via the question of the practical benefits of knowledge:

Is there any happiness as for a man's mind to be raised above the confusion of things, where he may have the prospect of the order of nature and the error of men? But is this a vein only of delight, and not discovery? of contentment, and not of benefit? . . . Is truth ever barren? Shall he not be able thereby to produce worthy effects, and to endow the life of man with infinite commodities? (*Works* viii.123)

The question is where these practical benefits, or the knowledge that yields them, is to be found:

But shall I make this garland be put on the wrong head? Would anybody believe me, if I should verify this upon the knowledge that is now in use? Are we the richer by one poor invention, by reason of all the learning that hath been these many hundred years? The industry of artificers maketh some small improvement of things invented; and chance sometimes in experimenting maketh us to stumble upon somewhat which is new; but all the disputation of the learned never brought to light one effect of nature before unknown. . . . All the philosophy of nature which is now received, is either the philosophy of the Grecians, or that other of the Alchemists. That of the Grecians hath the foundations in words, in ostentation, in confutation, in sects, in schools, in disputations. . . . That of the alchemists hath the foundation in imposture, in auricular traditions and obscurity; it was catching hold of religion, but the principle of it is, *Populus vult decipi*. So that I know no great difference between these great philosophies, but that the one is a loud crying folly, and the other is a whispering folly. The one is gathered out of a few vulgar observations, and the other out of a few experiments of a furnace. (*Works* viii.123-4)

The 'vain notions' of the philosophers and the 'blind experiments' of the alchemists are contrasted with the great inventions of printing, artillery, and the magnetic compass needle, which 'were stumbled upon and lighted upon by chance.' Bacon concludes that

10 See Quentin Skinner, *The Foundations of Modern Political Thought*, 2 vols. (Cambridge, 1978), i.214.

11 Martin, *Francis Bacon*, 64, remarks on the novelty of this approach.

the sovereignty of man lieth hid in knowledge; wherein many things are reserved, which kings with their treasure cannot buy, nor with their force command; their spials and intelligencers can give no news of them, their seamen discoverers cannot sail where they grow. Now we govern nature in opinions, but we are thrall to her in necessity; but if we would be led by her in invention, we should command her in action. (*Works* viii.125–6)

The political context of 'In Praise of Knowledge' here is evident, and it is striking that, in the 'Discourse in Praise of the Sovereign', which Bacon delivered to Elizabeth after that on knowledge, he explicitly begins by identifying the knowledge of the queen with the 'peace and serenity of her times.'¹² The implication is that genuine knowledge brings peace and serenity with it, whereas the 'knowledge' of zealots cannot be genuine for, the *Advertisement* tells us, it violates 'truth, sobriety, or peace.'¹³ The queen must take responsibility for natural knowledge into her own hands, and in 'Gesta Greyorum', his speech written for the Christmas celebrations at Gray's Inn in 1594, Bacon sets out just what she must do:

And for this purpose I will commend to your majesty four principal works and monuments of yourself: First, the collecting of a most perfect and general library, wherein whatsoever the wit of man hath heretofore committed to books of worth, be they ancient or modern, printed or manuscript, European or of the other parts, of one or other language, may be made contributory to your wisdom. Next, a spacious, wonderful garden, wherein whatsoever plant the sun of divers climates, out of the earth of diverse moulds, either wild or by the culture of man brought forth, may be with that care that appertaineth to the good prospering thereof set and cherished: This garden to be built about with rooms to stable in all rare beasts and to cage in all rare birds; with two lakes adjoining, the one of fresh water the other of salt, for like variety of fishes. And so you may have in small compass a model of universal nature made private. The third, a goodly huge cabinet, wherein whatsoever the hand of man by exquisite art or ingen hath made rare in stuff, form, or motion; whatsoever singularity chance and the shuffle of things hath produced; whatsoever Nature hath wrought in things that want life and may be kept; shall be sorted and included. The fourth such a still-house, so furnished with mills, instruments, furnaces, and vessels, as may be a palace fit for a philosopher's stone. (*Works* viii.335)¹⁴

12 *Works* viii.126.

13 *Works* viii.82.

14 On the question of progress in natural history up to Bacon's time, see William B. Ashworth, 'Natural History and the Emblematic World View', in David C. Lindberg and Robert S. Westman, eds., *Reappraisals of the Scientific Revolution* (Cambridge, 1990), 303–32; and Paula Findlen, 'Francis Bacon and the Reform of Natural History in the Seventeenth Century', in Donald R. Kelley, ed., *History and the Disciplines: The Reclassification of Knowledge in Early Modern Europe* (Rochester, 1997), 239–60.

This is the first version of what Bacon will later term Solomon's House, and indeed he mentions that Solomon 'was a man so seen in the universality of nature that he wrote an herbal of all that was green upon the earth.'¹⁵ It is a royal domain in which nature is contained, in both senses of the word, so that its most basic operations might be fathomed.¹⁶

The idea of a natural philosophy regulated by a sovereign was something that, in one form another, Bacon will continue to advocate, and part of the programme of convincing the sovereign was the vindication of the natural-philosophical enterprise. With the accession of James I to the throne, Bacon finally believed that there was a monarch who might adopt his schemes.

James I came to the English throne on 24 March 1603. Bacon's junior by five years, he was well-educated monarch, having had as one of his teachers the noted Scottish humanist George Buchanan, who had earlier tutored Montaigne. In March 1590, James, in Denmark to claim his wife, the daughter of Frederick II, visited Tycho Brahe, the greatest observational astronomer of the pretelescopic era, and Tycho's diary shows that James and he, with whom he had theological interests in common, stayed in conversation for seven hours.¹⁷ There is no evidence that Tycho harboured any great hopes of patronage from James, but he was clearly seen nevertheless as a figure sympathetic to developments in natural philosophy, and he will show great interest in the comet of 1618, for example, consulting a battery of mathematicians on it.¹⁸ Indeed, not

15 *Works* viii.334. Later in the *Advancement of Learning* he writes:

Salomon became enabled not only to write those excellent parables or aphorisms concerning divine and moral philosophy, but also to compile a natural history of all verdure . . . and also of all things that breathe or move. Nay, the same Salomon the king, although he excelled in the glory of treasure and magnificent buildings, of shipping and navigation, or service and attendance, of fame and renown, and the like, yet he maketh no claim to any of those glories, but only to the glory of inquisition of truth. (*Works* iii.298–9)

The loss of Solomon's writings, and the corpus of scriptural science more generally, was a common theme in seventeenth-century English natural philosophy, with writers as diverse as Browne, Fludd, and Boyle lamenting its loss. See Peter Harrison, *The Bible, Protestantism, and the Rise of Natural Science* (Cambridge, 1998), 137.

16 *Works* viii.335.

17 See Victor E. Thoren (with contributions by John R. Christianson), *The Lord of Uraniborg: A Biography of Tycho Brahe* (Cambridge, 1990), 334–5. Tycho had a portrait of Buchanan in his study, which may have been an earlier present from James. James granted Tycho a thirty-year copyright for his books.

18 See Mordechai Feingold, *The Mathematicians' Apprenticeship: Science, Universities and Society in England, 1560–1640* (Cambridge, 1984), 163. James's interest in these phenomena may have been motivated at least in part by mystical interests: See R. J. W. Evans, *Rudolf II and His World* (Oxford, 1973), 81.

only will various English astronomers, such as John Gostlin and John Bainbridge, devote treatises on the comets to him, but Kepler, whom James had invited to settle in England, was to dedicate what he considered his greatest work, and certainly the most comprehensive and fundamental account of his physical theory, his *Harmonice Mundi* (1619), to James. Despite his 'desire to meddle as little as I can in the King's causes',¹⁹ here was someone from whom Bacon might have expected support – support he had not received from Elizabeth – for his natural-philosophical project, a project that required the resources of the state if it was to succeed. The ambition that he now 'puts upon his pen' is something directed at a very practical outcome: the establishment of a centrally administered natural-philosophical programme. To achieve this, the programme first had to be set out, and this he does initially in a fragmentary way in *Valerius Terminus*, then in a more concrete and disciplined way in the *Advancement of Learning*. Both books of the *Advancement of Learning* not only have a dedication to James on their title pages but also directly refer to the king as reader in numerous passages, making the first book in particular seem more like an open letter to him. In addition, Book 2 begins by asking, '[W]hy should a few received authors stand up like Hercules' Columns, beyond which there should be no sailing or discovering, since we have so bright and benign a star as your Majesty to conduct and prosper us?', and Bacon sets out to consider (in detail – Book 2 is nearly two hundred pages long) 'of what kind those acts are, which have been undertaken and performed by kings and others for the increase and advancement of learning.'²⁰ There can be no doubt at all that Bacon intends the *Advancement of Learning* to secure the full support of the monarch for his own programme for the advancement of learning, that is, for the advancement of natural philosophy.

The religious vindication of natural philosophy

In the thirteenth century, Roger Bacon set out a model of the history of philosophy that offered a conception of the origins and development of learning which was common ground to many right up until the eighteenth century.²¹ Philosophy began, we are told, as a form of divine rev-

19 Letter to Cecil, 3 July 1603: *Works* x.80.

20 *Adv. Learn.* II: *Works* iii.321–2.

21 Roger Bacon, *Opus Maius*, ed. J. H. Bridges, 3 vols. (London, 1897–1900), iii.54–68. See the discussion in Paolo Rossi, *Francis Bacon: From Magic to Science* (Chicago, 1968), 69–70. Much the same version of events is alive and well not only in important sixteenth-century sources such as Benito Pereira's *De Communibus Omnium rerum Naturalium Principijs et Affectionibus Liber Quindecim* (Rome, 1576), and in Franciscus Toletus's *Commentaria una cum Questionibus in Octo Libros Aristotelis de Physica Auscultatione* (Venice, 1593), but also in the second half of the seventeenth century,

elation with Adam, to whom God revealed its fundamentals. It almost disappeared with the Fall, but bits were preserved by various wise 'men', namely Zoroaster, Prometheus, Atlas, Mercury, Hermes, Apollo, and Asclepius. Philosophy was revived in the time of King Solomon, and it was passed down to Democritus, Plato, and Aristotle, who offered confused and imperfect interpretations of the original revelation, interpretations which could only be corrected with the advent of Christianity.²²

This understanding of the history of philosophy was generally accepted in the seventeenth century, and the English divine Robert South sums it up with remarkable confidence in his 1692 *Sermons*:

[Adam] came into the world a philosopher, which sufficiently appeared by his writing the nature of things upon their names; he could view essences in themselves, and read forms with the comment of their respective properties; he could see consequents yet dormant in their principles, and effects yet unborn in their causes; his understanding could almost pierce into future contingents, his conjectures improving even to prophecy, or the certainties of prediction; till his fall it was ignorant of nothing but sin.²³

It is essentially this conception with which Bacon works, revising it and shaping it to his purposes. At the end of *Novum Organum*, he tells us:

as is evident from Georg Hornius, *Historiæ Philosophicæ Libri Septem ...* (Leiden, 1655), one of the principal histories of philosophy of the seventeenth century. This is interesting because these works are based on Diogenes Lærtius' *Lives of the Philosophers* (ed. and trans. R. D. Hicks, 2 vols. [Cambridge, Mass., 1925]), which sees philosophy as having Greek origins. Diogenes' account was routinely supplemented with an account of the pre-Greek origins of philosophy (in which Zoroaster was a key figure) in histories of philosophy, effectively up until the time of Brucker. See C. W. T. Blackwell, 'Thales Philosophicus: The Beginning of Philosophy as a Discipline', in Donald R. Kelley, ed., *History and the Disciplines: The Reclassification of Knowledge in Early Modern Europe* (Rochester, 1997), 61–82; and, more generally, see Giovanni Santinello et al., *Models of the History of Philosophy: I, From Its Origins in the Renaissance to the 'Historia Philosophica'*, gen. ed. (for English edition) C. W. T. Blackwell (Dordrecht, 1993).

22 That is, with the Incarnation, for Christianity was presumed to have existed in some way before the Incarnation, although it was not called Christianity of course. Augustine makes this clear:

What is now called Christian religion, has existed among the ancients, and was not absent from the beginning of the human race, until Christ came in the flesh; from which time true religion, which existed already, began to be called Christian. (*Retractions*, I.13)

It is in large degree because the true religion existed from the beginning of time that the true philosophy could exist from the beginning of the time: The two are inseparable.

23 Quoted in Harrison, *Bible, Protestantism*, 211–12.

By the Fall, man fell from both his state of innocence and from his dominion over creation. But even in this life both of those losses can be made good; the former by religion and faith, the latter by arts and sciences. (*Nov. Org.* II.52: *Works* i.365/iv.247–8)

The first appearance of this theme in Bacon's writings is in *Temporis Partus Masculus*, the subtitle of which is 'the great instauration of the dominion of man over the universe.' What is raised here is the question of the politicotheological role of natural philosophy, something that will play an important part in Bacon's thought. Bacon's politicotheology is not an easy part of his thought to capture, but it is crucial for an understanding of his natural philosophy, and more generally it is something that lies behind much natural philosophy in seventeenth-century England. The idea of restoration of human domination over nature in the modern era is not specific to the seventeenth century. We can find it as early as the twelfth century, in Hugh of St Victor,²⁴ and, more important, it had been set out in 1584 by Giordano Bruno, in his *Spaccio de la bestia trionfante*, published while he was in England. Bruno points out that God endowed human beings with a capacity superior to other animals:

The gods had given intellect and hands to man and had made him similar to them, giving him power over the other animals. This consists in his being able not only to operate according to his nature and to what is usual, but also to operate outside the laws of that nature, in order that by forming or being able to form other natures, other paths, other categories, with his intelligence, by means of that liberty without which he would not have the above-mentioned similarity, he would succeed in preserving himself as god of the earth.²⁵

In the Golden Age, Bruno tells us, men managed to raise themselves up out of their idleness, and separating themselves more and more from their animal natures by 'their solicitous and urgent occupations, they more closely approach divine being.'²⁶

Like Bruno, Bacon will argue that if we are to pursue natural philosophy, and learning more generally, we should overcome our animal natures; in fact Bacon will offer a coherent theory about how we are to achieve this which goes beyond anything in Bruno. Moreover, their understandings of the connections between politics and natural philosophy are very similar. For neither of them is the connection a direct one; rather, it is mediated by theology.²⁷ In Bacon it is mediated by a very spe-

24 See *ibid.*, 61–2.

25 Giordano Bruno, *The Expulsion of the Triumphant Beast*, ed. and trans. Arthur D. Imerti (New Brunswick, 1964), 205.

26 *Ibid.*, 206.

27 On Bruno's politicotheological aspects of Bruno's natural philosophy, see Frances Yates, *Giordano Bruno and the Hermetic Tradition* (Chicago, 1964).

cific understanding of theology and, in particular, by a theological understanding of two things: the synchronic relation among the different parts of Creation, and the diachronic relation among the different stages in the development of the created world. In raising these questions, Bacon is addressing the issue of the present possibility of a natural philosophy, that is, of an understanding of and ability to control natural processes simply by drawing on the resources of natural philosophy. This is a possibility effectively denied on the one hand in Golden Age conceptions, whereby the world has been in decline since antiquity, or perhaps since the Fall, and on the other hand by millenarian conceptions, whereby any real understanding cannot be achieved until the unfolding of a providential process has been completed, that is, until the end of, or at least the very last days of, the world. The question of restoring the 'dominion of man over the universe' is not something that can be addressed seriously without understanding the politicotheological context that points it up as a problem in the first place.

Natural philosophy, for Bacon as for his contemporaries, was a theory about nature understood as a creation of a Christian God, whether it took its models from Plato, Aristotle, Democritus, or the Stoics, just as much as ethics was about Christian happiness, whatever its classical models.²⁸ In his *Confession of Faith*, written before the summer of 1603, Bacon set out an account of nature that begins to provide the politico-theological context for his thought:

He created heaven and earth, and all their armies and generations, and gave unto them constant and everlasting laws, which we call *Nature*, which is nothing but the laws of creation; which laws nevertheless have had three changes or times, and are to have a fourth and last. The first, when the matter of heaven and earth was created without forms: the second, the *interim* of every day's work: the third, by the curse, which notwithstanding was no new creation, but a privation of part of the virtue of the first creation: and the last, at the end of the world, the manner whereof is not yet revealed. So as the laws of Nature, which now remain and govern inviolably till the end of the world, began to be in force when God first rested from his works and ceased to create; but received a revocation in part by the curse, since which time they change not. (*Works* vii.220–1)²⁹

The 'curse' referred to here is the Fall, or at least what resulted in the Fall. Since the Fall, nature appears differently, but Bacon stresses God's foreknowledge and foreordination, so that nature is still following a

28 This point about the understanding of natural philosophy is brought out well in the case of Melanchthon in Sachiko Kusukawa, *The Transformation of Philosophy: The Case of Philip Melanchthon* (Cambridge, 1995), and in the case of Bodin in Ann Blair, *The Theater of Nature: Jean Bodin and Renaissance Science* (Princeton, 1997), chap. 4.

29 On the dating of this work, which was first printed in 1648, see *Works* vii.216.

foreordained plan, and this provides the ground for an orderly conception of nature.³⁰ It is such a conception that provides the background to Bacon's project of seeking to restore human dominion over nature, a restoration which consists neither in a return to some prelapsarian state nor in some millenarian ending to the world. This marks him out from those who simply assumed that the human dominion over nature that characterised our relation to nature in the Garden of Eden could not be restored except by God, a view he is at pains to attack in the *Valerius Terminus*.

The first chapter of the *Valerius Terminus*, which is entitled 'Of the limits and ends of knowledge', begins with what is effectively a gloss on *Genesis*. The point of an almost exclusively theological approach to a natural-philosophical topic is revealed a few paragraphs later, where Bacon inveighs against those who would 'offer too great a restraint to natural and lawful knowledge, being unjustly jealous that every reach and depth of knowledge wherewith their conceits have not been acquainted, should be too high an elevation of man's wit, and a searching and ravelling too far into God's secrets.'³¹ Indeed, Bacon sees the pursuit of natural philosophy neither in terms of knowledge for its own sake, nor in terms of particular useful ends, but in terms of the restoration of human dominion over nature:

And therefore it is not the pleasure of curiosity, nor the quiet of resolution, nor the raising of the spirit, nor victory of wit, nor faculty of speech, nor lucre of profession, nor ambition of honour or fame, nor inablement for business, that are the true ends of knowledge; some of these being more worthy than other, though all inferior or degenerate: but it is a restitution and reinvesting (in great part) of man to the sovereignty and power (for whensoever he shall be able to call animals by their true names he shall command them) which he had in his first state of creation. And to speak plainly and clearly, it is a discovery of all operations and possibilities of operations from immortality (if it were possible) to the meanest mechanical practice. (*Val. Term.: Works* iii.222)

The point is pursued in a more detailed, if somewhat more enigmatic way, in *De Sapientia Veterum*, composed in 1608 and published in the next year. Here, after having earlier rejected the pursuit of the history of natural philosophy via the study of myth,³² he changes tack and decides

30 See Benjamin Milner, 'Francis Bacon: The Theological Foundations of *Valerius Terminus*', *Journal for the History of Ideas* 58 (1997), 245–64, at 256, who detects a distinctively Calvinist doctrine here.

31 *Val. Term.: Works* iii.219.

32 *Cog. & Vis.: Works* iii.600; Benjamin Farrington, *The Philosophy of Francis Bacon: An Essay on Its Development from 1603 to 1609 with New Translations of Fundamental Texts* (Chicago, 1964), 81–2. Compare the *Filium Labyrinthi*, where the myth is associated with the birth of magic, alchemy, and astrology: *Works*, iii.503.

to develop and exploit to the full the interpretation of ancient myths.³³ Two of these myths bear directly on the theological vindication of natural philosophy

The myth of 'Actæon and Pentheus, or curiosity' deals with the highly charged question of *curiositas*, curiosity.³⁴ Actæon and Pentheus each see what they were not supposed to see and are punished as a result: Actæon accidentally sees Diana naked and is turned into a stag, whereas Pentheus tries to spy on the secret mysteries of Bacchus and as a result is stricken with a madness whereby he sees everything double. Bacon interprets the first myth as relating to the secrets of princes, the second as relating to the secrets of divinity. His account of the second uses the image of two suns: The light of nature and the light of divinity are, we are told, two different things, and to try to use both will only lead to confusion. One well-known doctrine that Bacon possibly has in mind here is Augustine's doctrine of spiritual illumination. Augustine had argued that just as we need natural light, whose source is the sun, to illuminate sensible objects if we are to be able to be aware of them, so too we need a form of spiritual illumination if we are to be able to comprehend intellectual matters, and the source of this illumination is God, and it takes the form of grace. The doctrine became very popular, especially, but by no means exclusively, in Protestant circles in the sixteenth and seventeenth centuries, and it is clearly crucial for Bacon's purposes that our ability to pursue natural philosophy not depend on grace: As we have

33 See the discussion in Rossi, *Francis Bacon: From Magic to Science*, 81–96. Bacon's account of the myths he analyses follows rather closely Natale Conti's encyclopædic *Mythologiae sive Explicationis Fabularum Libri X* (Venice, 1551), as is shown in Charles W. Lemmi, *The Classical Deities in Bacon* (Baltimore, 1933). On Conti and his influence generally, see the discussion in Jean Seznec, *The Survival of Pagan Gods* (Princeton, 1973), 279–323.

34 On this question, see Hans Blumenberg, *The Legitimacy of the Modern Age* (Cambridge, Mass., 1983), esp. Part IV (pp. 229–452). Blumenberg presents a detailed and persuasive argument that the legitimacy of *curiositas* is one of the defining features of modernity. See also his *The Genesis of the Copernican World* (Cambridge, Mass., 1987), where he points out that 'The competition between concern for salvation in the next world and pleasure in seeing the stars becomes obligatory in the Middle Ages largely in the formulas that Augustine had coined in his discussion of *curiositas*' (p. 30). Paraphrasing Augustine's *De Doctrina Christiana* II.xxix.46, he notes that 'heavenly bodies were mentioned only rarely in Scripture; consequently, dealings with the science of those bodies were not very useful or not useful at all, in dealing with the divine Scriptures, and were more likely to interfere, by uselessly burdening one's attention. Consequently [in Augustine's view] it was more beneficial and honorable to desist from astronomy altogether' (p. 31). See also the extensive treatment of the history of *curiositas* in Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150–1750* (New York, 1998).

seen, there is quite a particular and definite threat here, from the zealotry that Bacon identified in the *Advertisement touching Controversies in the Church of England*.³⁵ His response here is twofold: to separate religious from natural-philosophical questions, and to argue that the degree of 'curiosity' we are allowed in natural philosophy is quite different from that allowed in theology. There are very strict limits in the latter that are not appropriate in the former.

The myth of 'Prometheus, or the state of man' also deals with the question of curiosity and its punishments, but Bacon's treatment here is more elaborate. The general thrust of his argument is similar, his conclusion being that 'men must soberly and modestly distinguish between things divine and human, between the oracles of sense and of faith; unless they mean to have at once a heretical religion and a fabulous philosophy.'³⁶ Prometheus is an ambiguous figure, however: He remedies human defencelessness by stealing fire from heaven, and this makes the mechanical arts possible, but he thinks himself divine as a consequence of his actions. Bacon's assessment of Prometheus mirrors this ambivalence. The response to Prometheus' theft of fire was to denounce him to the gods, and this is in effect a denunciation of science, but Bacon does not treat this as an act of ingratitude. On the contrary, he argues that

they who extravagantly extol human nature as it is, and the arts as they are received, and who spend their time admiring what they possess and hold up as perfect those sciences which are professed and cultivated, are wanting, first in reverence to divine nature, for they presume to compare with its perfection, and second in usefulness to human beings, in that they think they have already reached the summit of things and completed their work, and therefore need seek no further. Those who arraign and accuse nature and the arts, on the other hand, and offer lots of complaints, are not only more modest in their sentiments, if the truth be known, but are continually stimulated to make fresh industry and new discoveries. (*De Sap. Vet.: Works* vi.672/749–50)

The gods responded to the denunciation of Prometheus with new gifts, which were carried on the back of a slow-moving ass, who represents slow, painstaking empirical research. It is not easy to understand exactly what Bacon is driving at here. Certainly there is something illegitimate about Prometheus' theft of fire, but not about the possession of fire by

35 Although they are one of the few groups he identifies, the practice of pursuing natural philosophy on religious grounds is not confined to Puritans. In *Novum Organum*, Bacon certainly has a wider target in mind – possibly Paracelsians – when he criticises those who 'attempt to found a system of natural philosophy on the first chapter of Genesis, on the book of Job, and other parts of the sacred writings' (*Works* i.178/iv.66).

36 *De Sap. Vet.: Works* vi.675/753.

human beings. It is the mode of acquisition that is wrong, and for which Prometheus is being condemned. Now without Prometheus' theft, human beings would not have had fire, that is, the mechanical arts and sciences. Bacon seems to be saying that in this case the mechanical arts and sciences would be illegitimate. He certainly considers that had certain things – the magnetic compass needle and gunpowder, for example – been discovered in a systematic way, instead of by chance, we would have learned a great deal more, and have been empowered to do a great deal more. Moreover, he believes that alchemical procedures are often illegitimate, something which perhaps taints alchemical discoveries; so things can be discovered in the wrong way, and this is in a sense an illegitimate discovery. However, it is not clear that this is what Bacon has in mind, for immediately after the passage quoted above, he seems to contrast the correct reaction to Prometheus on the part of his fellow men with the incorrect reaction of most of his predecessors and contemporaries to Aristotle, since every attempt to find fault with Aristotle 'has come to be not only useless, but also suspected and almost dangerous.' Bacon's criticism of Aristotle is not that his discoveries have been illegitimate, but that he has made no discoveries at all (at least in natural philosophy). The point here seems to be that we should not rest content with particular achievements, whether real or imagined, but should always be critical of them, so that we can go beyond them. Yet this is hardly plausible as an interpretation of those who denounced Prometheus.

What is interesting about Prometheus myths, and what makes them so overdetermined, is the meeting of pagan and Judæo-Christian mythologies. The Church Fathers Tertullian and Lactantius established a close connection between the story of Prometheus and Creation. In his *Divinae institutiones*, Lactantius maintained that it is wrong to question the legitimacy of the transfer of fire from heaven to earth, for example, because the possession of fire, which is characteristic of the stars and points upwards, is what marks man out as a celestial creature. Other animals can make use of earth, air, and water, but the use of the highest element, fire, is denied to them. In the Renaissance we find a new factor, a connection between Prometheus and Adam, or between Prometheus and Cain, and Blumenberg, for one, has argued that this association is present in Bacon.³⁷ Glossing Bacon's project for the regaining of the dominion of man over nature, he points out that Bacon's conception of modernity was one in which human beings could regain Paradise through their own efforts. Upon their expulsion from Paradise, Adam and Eve and their progeny had to secure their own conditions for survival, and this is in effect what Prometheus, in a different mythology, achieves. As

37 See Hans Blumenberg, *Work on Myth* (Cambridge, Mass., 1985), 350–75, to which my account in this paragraph is indebted.

Blumenberg points out, 'if Prometheus was projected onto Adam, that could only mean the loss of Paradise was supposed to be seen as a *felix culpa* (fortunate fault): as man's opportunity to be himself on his own account, irrespective of what had brought him to that point.'³⁸ But another association, of which Bacon could hardly have been unaware, is that between Prometheus and Cain. In 1499 Erasmus wrote a letter setting out a debate he had had with John Colet. Colet had argued that Cain, in placing his trust in the tilling of the soil, rather than in God, had offended God. The contrast is with Abel, who, as Blumenberg puts it, 'still behaves as though he were situated in Paradise, and were not the offspring of parents who have been driven out of it, while Cain does exactly what would have had to follow obviously from this fate of exile, and what accords with the curse that went with it: he places his trust only in toil and in the sweat of his brow.'³⁹ The pressing question that this poses, a question on which the dispute between Colet and Erasmus turns, is how seriously we take the expulsion from Paradise: Does it throw human beings wholly onto their own resources, and if so what kind of dependence on God remains? No wonder Bacon's position on this question is somewhat ambiguous. It all very well to say that one must draw a line between things divine and things human, as Bacon does, but that was hardly what was in dispute: The problem was rather where exactly the line was to be drawn, and there can be no doubt that Prometheus-cum-Adam-cum-Cain is the point at which the separation between human beings and God takes place and, as such, just what this separation amounts to, and what its legitimacy consists in, is a crucial issue. Paracelsus, for one, had seen the Fall as a *felix culpa*, not a tragedy but an opportunity. Before the Fall, Adam may have been happy and innocent but he lacked the 'light of nature', with which he was provided only when he was expelled from Paradise. By following this light of nature, we may regain mastery over nature, but only by slow, laborious, and methodical steps. Bruno, in an even more radical interpretation, had read the biblical account through Virgil's *Georgics*, in which Jupiter brings the Golden Age to an end, with the result that people are driven by necessity to devise new skills, invent new industries, and sharpen their wits, leading to material and moral improvement.⁴⁰

When read in this context, Bacon's gloss perhaps becomes a little clearer. Despite the fact that Prometheus is effectively the inventor of the mechanical arts in the myth, Bacon cannot unambiguously allow Prometheus a heroic standing, for to do so would be to advocate a form of

³⁸ Ibid., 361.

³⁹ Ibid., 368.

⁴⁰ See James R. Jacob, *The Scientific Revolution* (New Jersey, 1998), chap. 2; and Harrison, *Bible, Protestantism*, chap. 6.

humanism in which God is effectively replaced, made redundant, as human beings shape their own conditions of existence (and hence, to some extent, destiny) without help from or dependence upon God. On the other hand, he cannot seriously countenance any dependence upon God, precisely because he does want to make natural philosophy something that relies exclusively on human resources. As Bacon points out, God favoured Abel over Cain; but it is at best ambiguous whom Bacon favours.

The political vindication of natural philosophy

Many of these themes are followed up in Book 1 of the *Advancement of Learning*, which offers an extensive vindication of natural philosophy. The weight of the argument moves from a religious to a political vindication, although the two are never wholly separate. As we saw in Bacon's attacks on zealots, who try to substitute revelation for learning, it is the fact that they undermine the well-ordered state that stands out as their ultimate sin.⁴¹ There are theological and political aspects to knowledge, and there are ways of pursuing it which violate what Bacon considers the basic precepts of learning. Dominion over nature, which, as we have just seen, is the ultimate aim of natural philosophy, is to be achieved through a particular mentality which enables one to conceive of it and understand it in a particular way. It will be in Bacon's treatment of internal impediments, the 'Idols of the mind', that the question is raised of what psychological or cognitive 'state' we must be in to be able to pursue natural philosophy in the first place. He will only hint at the contents of this doctrine in *Valerius Terminus* and the *Advancement of Learning*, but he does make the general point that the problem lies in the impediments to knowledge, rather than in knowledge itself. Discussing Ecclesiastes, for example, in the *Advancement of Learning*, he glosses the passage which tells us that God 'hath placed the world in man's heart, yet cannot man find out the work which God worketh from the beginning to the end.' His gloss on the passage is that it tells us

not obscurely that God hath framed the mind of man as a mirror or glass capable of the image of the universal world, and joyful to receive the impression thereof, as the eye joyeth to receive light; and not only delighted in beholding the variety of things and vicissitude of times, but raised also to find out and discern the ordinances and decrees which throughout all those changes are infallibly observed. And although he doth insinuate that the supreme or summary law of nature, which he calleth the work which God worketh from the beginning to the end, is not possible to be found out by

41 Bacon will return to this point in *Novum Organum* (I lxxxix), referring to 'the blind and immoderate zeal of religion' (*Works* i.196/iv.87–8).

man; yet that doth not derogate from the capacity of the mind, but may be referred to the impediments, as of shortness of life, ill conjunction of labours, ill tradition of knowledge over from hand to hand, and many other inconveniences whereunto the condition of man is not subject. (*Adv. Learn. I: Works* iii.265)⁴²

Nevertheless, the focus in the *Advancement of Learning* is on the benefits of natural philosophy, pursued in the right manner, rather than on the question of what exactly fits us to pursue it in the right manner. Indeed, in a sense this is a prior question for Bacon, because natural philosophy, as he perceives it, is necessarily a large-scale enterprise requiring the resources of the state – the aim of the *Advancement of Learning*, in particular, being to convince the sovereign to support this large-scale enterprise.

Book 1 of the *Advancement of Learning* deals with ‘the excellency of learning and knowledge, and the excellency of the merit and true glory in the augmentation and propagation thereof.’ In pursuit of this aim, Bacon finds it necessary, before he turns to its merits, to deal first with various objections to the advancement of learning, all of which, he tells us, derive from ignorance, ‘but ignorance severally disguised; appearing sometimes in the zeal and jealousy of divines, sometimes in the severity and arrogance of politiques, and sometimes in the errors and imperfections of learned men themselves’ (iii.263, 264).

It might seem that these are somewhat localised, marginal issues, but in fact they raise a question that is central to the transition to modernity, that of what we should aspire to know and what we should not aspire to know. This is particularly clear in the first class of objections, those deriving from divines, which are designed to impose severe limitations on knowledge. Seeking to know too much, they claim, was what led to Adam’s Fall; it makes its seekers swollen-headed, it leads to increased anxiety, to heresy, atheism; and finally ‘the contemplation of second causes’, which is what natural philosophy investigates, ‘doth derogate from our dependence upon God, who is the first cause’ (iii.264). These criticisms, which effectively date back to Augustine, shaped mediæval culture; but the transformation of curiosity, conceived of as something active and probing, from a vice into a virtue, and the corresponding transformation of wonder, conceived of as something contemplative and respectful, from something proper and wholesome into something that is characteristic of an ignoramus, is a distinctive feature of the transition to modernity.⁴³

42 Subsequent citations in this section to Book 1 of the *Advancement of Learning* will be given parenthetically in the text solely by *Works* volume and page.

43 See Daston and Park, *Wonders and the Order of Nature*.

Bacon shows in some detail that the objections of the divines are mistaken. In the first place, it was not 'the pure knowledge of nature and universality, a knowledge by the light whereof man did give names unto other creatures in Paradise . . . according to their properties' that caused the Fall, but rather the search for knowledge of good and evil, that is, a grasp of the nature of good and evil that underlay God's commandments but were not revealed therein. In seeking this knowledge, Adam was seeking to bypass God, as it were, and so become independent of Him. Moreover, when Solomon condemns the work of the mind, he does not condemn it as such, but rather the impediments to knowledge that are in the mind (and which Bacon will seek out and try to correct in his doctrine of the 'Idols'). Second, Solomon does not condemn the quantity of knowledge but its quality, so the idea of seeking after ever more knowledge making one swollen-headed receives no support there. The solution to swollen-headedness, Bacon argues, is charity; that is, the benefits of one's knowledge 'must be referred to the good of men and mankind' (iii.266). Third, as regards anxiety, this cannot result from knowledge itself, 'for all knowledge and wonder (which is the seed of knowledge) is an impression of pleasure in itself', but must derive rather from the framing of particular conclusions, or applying it to particular circumstances. In general, we should not place so much faith in our knowledge that it overrides our morality; we should apply our knowledge 'to give ourselves repose and contentment'; and we should not presume to attain to the mysteries of God. Finally, 'as for the conceit that too much knowledge should incline a man to atheism, and that the ignorance of second causes should make a more devout dependence upon God which is the first cause' (iii.267), Bacon dismisses both of these. Of course we work through second causes, since 'God worketh nothing in nature except by second causes', and so this is all to which we have access; but we do not suppose that these replace first causes, for when we examine them properly we see the work of providence.

The second kind of objections to the advancement of learning derive from political considerations. It is said

that learning doth soften men's minds, and makes them more unapt for the honour and exercise of arms; that it doth mar and pervert men's dispositions for matter of government and policy, in making them too curious and irresolute by variety of reading, or too peremptory or positive by strictness of rules and axioms, or too immoderate or overweening by reason of the greatness of examples, or too incompatible and differing from the times by reason of the dissimilitude of examples; or at least that it doth divert men's travails from actions and business, and bringeth them to a love of leisure and privateness; and that it doth bring into states a relaxation of discipline, whilst every man is more ready to argue than to obey and execute. (iii.268)

These objections are met mainly by counterexamples taken almost exclusively from classical Rome. There are great military leaders who were learned men (Alexander the Great and Julius Cæsar, for instance) and great rulers who were learned men (such as Seneca in Nero's minority). Learning may make men perplexed and irresolute, but it teaches them the remedy: on what basis questions might genuinely be resolved. It may make them 'positive and regular', but it teaches them what things are conjectural and which can be demonstrated, and what latitude rules have. It can mislead 'by dissimilitude of examples', but it teaches them the potential errors of comparisons and the caution due in applying them. And so on: Where learning can create problems, it also has the remedies for them.

The third kind of objections derive from learned men themselves, and they have three sources: 'either from their fortune, or from their manners, or from the nature of their studies' (iii.274). As regards their fortune, Bacon has two main complaints: First, because learned men do not usually grow rich like others, they 'convert not their labours chiefly to lucre and increase' (iii.275),⁴⁴ that is, among other things, any practical benefits of their learning have a low priority; and second, he laments the low expenditure on and poor state of education in England, praising the teaching of the Jesuits (iii.277).⁴⁵ On the question of the 'manners' of learned men, Bacon can find no great fault here, except that, studying the events of better times than their own, they offer models of perfection that go beyond what is achievable (iii.277).⁴⁶ However, the degree to which this is really a fault is debatable, and Bacon quotes Cicero's remark that aiming beyond the mark and falling short should land us in the right place (iii.278). Indeed, Bacon's general response to criticism of the distinctive habits of mind of the learned is to show that they are not faults at all, or at worst minor ones. The faults deriving from the nature of the studies of the learned – 'delicate learning', 'contentious learning', and 'fantastical learning' (iii.282) – are a different matter, and these receive more detailed attention. The first Bacon associates with Luther, although it is the humanist movement more generally that he has in his sights, arguing that 'the admirations of ancient authors, the hate of schoolmen, the exact study of languages, and the efficacy of preaching,

44 Feingold points out that a fellow of an Oxford or Cambridge college 'was forbidden, on pain of forfeiting his fellowship, to accept any preferment or living which carried with it remuneration above a specified sum, again usually quite modest' (*Mathematicians' Apprenticeship*, 170).

45 He quotes Agesilaus: 'they are so good that I wish they were on our side.'

46 Bacon gives a good instance of this, as noted by Cicero: 'Cato means excellently well; but he does hurt sometimes to the state; for he talks as if it were Plato's republic that we were living in, and not the dregs of Romulus' (*Works* iii.278).

did bring in an affectionate study of eloquence and copie of speech, when then began to flourish' (iii.283). This kind of approach results in 'a delicate and polished kind of learning', which values style over content. Note, however, that the object of Bacon's criticism here is the *excess* of eloquence, not eloquence itself, which he believes important to the imparting of knowledge. He identifies two signs of the second fault – 'the one, the novelty and strangeness of terms; the other, the strictness of positions, which of necessity doth induce oppositions, and so questions and altercations' – both of which he associates with the Scholastics, offering a striking image of Scholastic learning which has a more general bearing on the pursuit of learning without empirical investigation:

For the wit and mind of man, if it work upon matter, which is the contemplation of the creatures of God, worketh according to the stuff, and is limited thereby; but if it work upon itself, as the spider worketh his web, then it is endless, and brings forth indeed cobwebs or learning, admirable for the fineness of thread or work, but of no substance or profit. (iii.285–6)

The third fault is twofold: imposture and credulity, or an aptness to deceive and an aptness to be deceived. The common core lies in accepting things without proper warrant. Bacon mentions miracles and the like being accepted simply through ignorance, although his main concern here is with astrology, natural magic, and alchemy. The ends of these disciplines are noble, he tells us, but the results produced are false and vain, a fact which their practitioners have sought 'to veil over and conceal by enigmatical writings, and referring themselves to auricular traditions, and such other devices to save the credit of impostures' (iii.289).

In the final pages of his account of the deficiencies of current learning, Bacon raises the question of the authority of earlier writers in an interesting way. Noting that they have often been made into dictators, with the result that progress has been stunted, he sets out a crucial difference between what we might now call the humanities and the sciences, but which he refers to as the sciences and the mechanical arts, respectively:

[I]n arts mechanical the first deviser comes shortest, and time addeth and perfecteth; but in sciences the first author goes furthest, and time leeseth and corrupteth. So we see, artillery, sailing, printing, and the like, were grossly managed at the first, and by time accommodated and refined; but contrariwise the philosophies and sciences of Aristotle, Plato, Democritus, Hippocrates, Euclides, Archimedes, of most vigour at the first, and by time degenerate and imbasd; whereof the reason is no other than that in the former many wits and industries have been spent about the wit of some one, whom many times they have rather depraved than illustrated. For as water will not ascend higher than the level of the first spring-head from whence it descendeth, so knowledge derived from Aristotle, and exempted from liberty of examination, will not rise again higher than the knowledge of Aristotle. (iii.289–90)

As well as these three 'diseases of learning', Bacon draws attention to a number of less-developed defects. Paramount among these is a belief that it is unlikely that there is anything that has been overlooked in the development of learning to this time.⁴⁷ This is a view which was strongly repudiated in a number of early-modern authors, and the achievements of antiquity were assessed with some severity. Cardano, for example, had pointed out in Book 17 of his *De Subtilitate* (1550) that there were all kinds of inventions unknown to the ancients – domestic furnaces, church bells, stirrups on saddles, counterweights in clocks, and so on – which it would take more than a book to list.⁴⁸ Jean Bodin, in his *Methodus ad Facilem Historiarum Cognitionem* (1566) defends the superiority of the modern age, arguing that the so-called Golden Age was one of barbarism and gratuitous violence.⁴⁹ Louis Le Roy, in his *De la vicissitude ou variété des choses en l'univers* (1575), translated into English in 1594 as *Of the Interchangeable Course, or Variety of Things in the Whole World*,⁵⁰ sets out in detail the historical case for the idea that the modern age is superior in every respect to earlier ages, and presents his case in a way that will find echoes in Bacon:

And let vs not be so simple, as to attribute so much vnto the Auncients, that wee beleeeue that they haue knowen all, and said all; without leauing anything to be said, by those that should come after them. . . . Let vs not thinke that nature hath giuen them all her good gifts, that she might be barren in

47 We can find a variant on this belief forming part of the resistance to the innovations of the Royal Society in the seventeenth century. Catherine Wilson, in her *The Visible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton, 1995), points out that 'The Royal Society's interest in manufacturing processes, navigational aids, and agriculture might have seemed easy to defend as economically significant. But Thomas Sprat had to argue that this was so, and that the mechanical arts were not, as was commonly believed, incapable of further improvement or subject to improvement only by the chance inventions of artisans themselves' (p. 32).

48 Girolamo Cardano, *Opera Omnia*, 10 vols. (Leiden, 1663), iii.609.

49 The text can be found in Jean Bodin, *Oeuvres philosophiques*, ed. Pierre Mesnard (Paris, 1951).

50 The book was translated by a lawyer of the Middle Temple, Robert Ashley, and was published by the holder of the royal patent for the printing of law books in 1594 – the only nonlaw book he ever published (see Francis R. Johnson, *Astronomical Thought in Renaissance England: A Study of English Scientific Writings from 1500 to 1645* [Baltimore, 1937], 297). These circumstances alone make it unlikely that Bacon was not familiar with it. See Herschel Baker, *The Wars of Truth* (Gloucester, Mass., 1969), 70–2, on the controversy it generated. Le Roy's approach is followed in Henri La Popelinière, *Histoire des histoires, avec l'Idée de l'histoire accomplie* (Paris, 1599). See the discussion in Donald R. Kelley, 'History as a Calling: The Case of La Popelinière', in Anthony Molho and John A. Tedeschi, eds., *Renaissance Studies in Honour of Hans Baron* (Florence, 1971), 771–89.

time to come: but that as she hath in times past brought forth certaine notable personages, who haue manifested many of her secrets; so she can again bring forth, such as by the influence of heauen, and a singular inclination, by liuelynes of understanding, and perseuerance of labour, shall attain thither; whither long experience, diligent obseruation, and subtiltie of reason, haue not pierced till this present. . . . All the mysteries of God and secrets of nature, are not discovered at one time. The greatest things are difficult, and long in coming. How many are there, not as yet reduced into art? How many haue bin first knowen and found out in this age? I say, new lands, new seas, new formes of men, maners, lawes, and customes; new diseases, and new remedies; new waies of the Heauen, and of the Ocean, neuer before found out; and new starres seen? yea, and how manie remain to be known by our posteritie? That which is now hidden, with time will come to light; and our successours will wonder that wee were ignorant of them.⁵¹

Bacon, who was doubtless aware of these works,⁵² will pursue the theme in his *Cogitata et Visa* (1607), pointing out that the adage 'truth is the daughter of time' means that the maturity of the modern era, compared to antiquity, enables it to achieve far greater things than was possible in antiquity.⁵³ In the *Advancement of Learning*, Bacon concentrates on the misconceptions that have led people to think otherwise. He points out that, often, before something radically new is done, it is considered impossible, whereas when it has been achieved, it is often regarded as surprising that it was not done earlier – Alexander's expedition into Asia, Columbus's western navigation, and so on (iii.291).⁵⁴ A related error is that of believing that the best opinions have risen to the surface over time, pushing the rest down into oblivion, so that someone setting out to discover something new is likely only to disturb and raise opinions

51 Loys Le Roy, *Of the Interchangeable Course, or Variety of Things in the Whole World* (London, 1594), fols. 127^r–127^v.

52 I have already indicated that he would have been familiar with Le Roy's book. He would certainly have been familiar with the other authors from an early stage. As regards Bodin, for example, Gabriel Harvey, a slightly older contemporary of Bacon, writes that in Cambridge in the 1560s and 1570s (when Bacon was there): 'You can not steppe into a scholars studye but (ten to one) you shall finde open either Bodin de Republica or Le Royes Exposition uppon Aristotles Politiques.' *The Letter Book of Gabriel Harvey A.D. 1573–1580*, ed. E. J. L. Scott (London, 1884), 79. See the discussion in Stephen Pumfrey, 'The History of Science and the Renaissance Science of History', in Stephen Pumfrey, Paolo L. Rossi, and Maurice Slawinski, eds., *Science, Culture and Popular Belief in Renaissance Europe* (Manchester, 1991), 48–70.

53 *Cog. & Vis.: Works* iii.612; Farrington, *Philosophy of Francis Bacon*, 94.

54 Bacon treats this as being the same as the geometrical case:

[A]s may be seen in most of the propositions of Euclide, which till they be demonstrate, they seem strange to our assent; but being demonstrate, our mind accepteth of them by a kind of relation (as the lawyers speak) as if we had known them before. But the two cases are surely very different.

that have been rightly rejected. Bacon argues that nothing could be further from the case:

as if the multitude, or the wisest for the multitude's sake, were not ready to give passage rather to that which is popular and superficial than to that which is substantial and profound; for the truth is, that time seemeth to be of the nature of a river or stream, which carrieth down to us that which is light and blown up, and sinketh and drowneth that which is weighty and solid. (iii.291–2)

Among the other defects that Bacon notes (iii.292–5) are the concentration on particular arts, to the exclusion of *philosophia prima*; the withdrawal from observation and experience into a world of one's own making, so that men 'have tumbled up and down in their own reason and conceits'; and the extrapolation from particular cases to the general, 'so have the alchemists made a philosophy out of a few experiments of the furnace; and Gilbertus, our countryman, hath made a philosophy out of the observations of a loadstone' (iii.293).⁵⁵ Some of the other errors turn on the question of doubt. There is an 'impatience of doubt', that is, an acceptance of theories before they have been properly judged. 'If a man will begin in certainties', Bacon tells us, 'he shall end in doubts; but if he will be content to begin with doubts, he shall end in certainties.' On the other side of the coin, knowledge is routinely presented in a 'magisterial and peremptory' way, since the aim is usually to make it most easily believed, not most easily criticised. The right way to present things, however, is to follow a middle path between Velleius the Epicurean, whose greatest fear was to appear to be in doubt over anything, and Socrates, who began by doubting everything. Finally, 'the greatest error of all the rest' is a failure to recognise the true ends of knowledge: The remedy is that contemplation and action must be 'more nearly and straitly conjoined and united together than they have been.' The ultimate aim is to

separate and reject vain speculation and whatsoever is empty and void, and to preserve and augment whatsoever is solid and fruitful; that knowledge may not be as a curtesan, for pleasure and vanity only, or as a bond-woman, to acquire and gain her master's comfort; but as a spouse, for generation, fruit, and comfort. (iii.294–5)

55 It is worth mentioning that it is likely that Bacon derived his knowledge of Gilbert not from his *De Magnete* but from his *Philosophia Nova*: Bacon had a copy of the manuscript of this, and the first and only edition of the work (1651) was based on Bacon's manuscript. On the evidence for Bacon's lack of knowledge of the *De Magnete*, see Marie Boas, 'Bacon and Gilbert', *Journal of the History of Ideas* 12 (1951), 466–7.

The disciplinary vindication of natural philosophy

Bacon's treatment of the myth of Prometheus goes beyond issues of allegory and raises questions about just what his attitude to the relation between natural philosophy and theology is. On the one hand, we have seen that he considers part of the problem with the natural philosophy of his time as lying in the continued domination of natural philosophy by theology, and that a sharp line must be drawn between things divine and things human. On the other hand, his account of the ultimate value of natural philosophy, namely the restoration of man's dominion over nature, is spelled out in explicitly biblical terms, and it seems unlikely that the contrast that Bacon is driving at is one between the secular and the religious.

In the wake of the struggles between science and religion that characterised the eighteenth-century French Enlightenment, and which came to a head in the bitter disputes over Darwinism in the nineteenth century, we might be tempted to think that we have the seeds of such disputes here; but we do not. The kinds of issues that shaped questions of the relation between theology and natural philosophy in the sixteenth and seventeenth centuries were quite different. Not only was the atheism which characterised many of the Enlightenment and Darwinist attempts to remove religious considerations from science absent in the sixteenth and seventeenth centuries, but in many respects seventeenth-century natural philosophy, particularly in England, was even more caught up with religious questions than mediæval or Renaissance thought. Natural theology came to turn on the theological implications of natural philosophy, and these implications were bitterly contested.⁵⁶

In the sixteenth century, the reconciliation, set out in detail by Aquinas, between Aristotelian metaphysics and Christian theology was beginning to come apart.⁵⁷ Aquinas argued that metaphysics included un-

⁵⁶ See, for example, from among the vast array on pieces on this subject, Richard S. Westfall, *Science and Religion in Seventeenth-Century England* (Ann Arbor, 1973), and Harrison, *Bible, Protestantism*. It had been a commonplace of Elizabethan science that religion and science should be kept separate, but on the other hand that they were complementary to one another: See Paul H. Kocher, *Science and Religion in Elizabethan England* (San Marino, Calif., 1953), 26–8.

⁵⁷ See Charles Lohr, 'Jesuit Aristotelianism and Sixteenth-Century Metaphysics', in G. Fletcher and M. B. Scheute, eds., *Paradosis* (New York, 1976), 203–20; 'Metaphysics', in Schmitt et al., eds., *The Cambridge History of Renaissance Philosophy* (Cambridge, 1988), 537–638; 'The Sixteenth-Century Transformation of the Aristotelian Natural Philosophy', in Eckhard Kessler, Charles H. Lohr, and Walter Sparn, *Aristotelismus und Renaissance* (Wiesbaden, 1988), 89–99; 'The Sixteenth-Century Transformation of the Aristotelian Division of the Speculative Sciences', in D. R. Kelley and R. H. Popkin, eds., *The Shapes of Knowledge from the Renaissance to the Enlightenment* (Dordrecht, 1991), 49–58.

der its rubric both uncreated or infinite being, and created or finite being. Hence, topics such as the nature of the matter and the nature of the soul, which had been treated as natural-philosophical issues, now came to fall under metaphysics – specifically, a metaphysics which graded reality in degrees from inert matter to God, so that the apparently sharp distinction between truths of reason and truths of revelation became blurred. So, for example, Suárez, in the most influential Scholastic treatise on metaphysics of the early-modern era, tells us that we must provide firm foundations in metaphysics before proceeding to theology, but that we must not forget that philosophy ‘is the servant of divine theology.’⁵⁸

One great advantage of this doctrine, from the church’s point of view, was that the ultimate authority in philosophical matters lay with the clergy, who alone could deal authoritatively with questions of revelation; but this introduced a political element into the equation, which turned out to be somewhat difficult to enforce. The trouble began in the northern Italian universities, which had traditionally been concerned to turn out physicians rather than theologians, and had seen natural philosophy very much as their own preserve. They offered an interpretation of Aristotle which turned on quite staunchly naturalistic natural-philosophy texts, such as the first two books of the *De anima*, in which there is no place for the transcendentals of the *Metaphysics*. The trigger was the doctrine of the immortality of the soul, which Aristotelian philosophers based at the University of Padua, most notably Pomponazzi, had argued is incompatible with Aristotelian natural philosophy.⁵⁹ In his *Tractatus de Immortalitate Animæ* (Bologna, 1516), Pomponazzi maintained that, from the point of view of (Aristotelian) natural philosophy, the soul was the form of the body, and there was no such thing as an un-instantiated form, so that the death and corruption of the body resulted in the disappearance of the soul, while on the other hand accepting on faith the church teaching of the personal immortality of the soul. A wedge was driven between theology and natural philosophy, although it is not always clear whether the wedge was between natural philosophy and metaphysics, or between natural philosophy plus metaphysics as the science of being on the one hand, and metaphysics as the science

⁵⁸ Francisco Suárez, *Disputationes Metaphysicæ* (1st pub. 1597; reprint Hildesheim, 1965 [of vols. 25 and 26 of *Opera Omnia*, ed. D. M. André, Paris, 1856–78]), Preface, n.p.

⁵⁹ There were a number of precedents for such a position, and Scotus for one had argued that the immortality of the soul is not demonstrable in philosophy, and is therefore a matter of faith. See Martin L. Pine, *Pietro Pomponazzi: Radical Philosopher of the Renaissance* (Padua, 1986), 56.

of God on the other.⁶⁰ Whatever the exact location of the divide, however, there can be no doubt that a gulf begins to open up between theology and natural philosophy, and it is the natural philosophy of the northern Italian philosophers – Pomponazzi, Zabarella, Nifo, Telesio – that forms the vanguard, with the teaching curriculum itself coming to reflect that divide by the late sixteenth century.⁶¹ This is in stark contrast to the case in France, for example, where Ramus's proposed reforms of the curriculum of the University of Paris were explicitly aimed at reinforcing the union of reason and faith.⁶²

It is this Italian vanguard that informs Bacon's thinking on natural-philosophical matters. If he is indebted to any natural philosophy of his own era, for example, it is that of Telesio, as we shall see in Chapter 6. Note that although the Italians were at the forefront of mechanics in the sixteenth century (and Galileo of course will emerge from this culture), the concern of these natural philosophers is not in fact mechanics but a reworking of Aristotelian natural philosophy which, in the main, has as little concern for quantitative questions as Aristotle himself had. Everything turns on matter theory, not just in the sense that natural philosophy is pursued through matter theory, but also because it is through matter theory that metaphysical theories about the nature of matter are incorporated into natural philosophy.

Matter theory, as we see in detail later, is Bacon's route to natural philosophy. Eschewing mechanics, he pursues natural philosophy exclusively through matter theory, arguing that the mathematical treatment characteristic of mechanics only touches the periphery, whereas accounting for the behaviour of physical bodies in terms of their constituent corpuscles reveals what lies at the basis of that behaviour, and so ultimately enables us to manipulate it. However, Bacon's indebtedness to Italian natural philosophy goes beyond a commitment to matter theory: It also

60 Lohr ('Metaphysics', 605ff) thinks the latter, arguing that metaphysics becomes philosophy in the sixteenth century; but when one considers Descartes's account of the nature of eternal truths, for example (see my *Descartes, an Intellectual Biography* [Oxford, 1995], 203–10), it is clear that metaphysical discussion in the seventeenth century can still engage core theological questions about the nature of God.

61 See Nicholas Jardine, 'Keeping Order in the School of Padua: Jacopo Zabarella and Francesco Piccolomini on the Offices of Philosophy' (pp. 183–210), and Heikki Mikkeli, 'The Foundation of an Autonomous Natural Philosophy: Zabarella on the Classification of Arts and Sciences' (pp. 211–28), both in Daniel A. Di Liscia, Eckhard Kessler, and Charlotte Methuen, eds., *Method and Order in Renaissance Philosophy of Nature: The Aristotle Commentary Tradition* (Aldershot, 1997). See also Umberto Pirotti, 'Aristotelian Philosophy and the Popularisation of Learning: Benedetto Varchi and Renaissance Aristotelianism', in Eric Cochrane, ed., *The Late Italian Renaissance 1525–1630* (New York, 1970), 168–208.

62 See his *Pro Philosophica Parisiensis Academiae Disciplina* (Paris, 1551), 40.

enables him to take a stand on the question of the autonomy of natural philosophy. Those who sought to impose a theological constraint on the way in which Pomponazzi pursued natural philosophy and those whom Bacon is criticising are, of course, different, but in general terms the issue is the same, whether it is evangelical Protestant zealots – ‘the blind and immoderate zeal of religion’, as he will refer to it in *Novum Organum*⁶³ – or Catholic religious orders, and it is an issue that transcends local political struggles. It is the issue of what the relation is between natural philosophy – a theory about nature understood (by Pomponazzi, Bacon, and by their opponents) as the creation of a Christian God – and theology, which is a theory about the nature of this Creator. The Prometheus myth, as we have seen, provides a crucial indicator of what kinds of resources we should employ in pursuing natural philosophy. The question of the extent to which we are dependent upon God, and to what extent we are thrown onto our own resources, mirrors that of the extent to which natural philosophy must ultimately be informed and regulated by theology,⁶⁴ and the extent to which it is an autonomous discipline.

One way in which the autonomy of natural philosophy is established is through the classification of knowledge offered in the *Advancement of Learning* and *De Augmentis*. Within what is in most respects a quite conservative classification,⁶⁵ Bacon incorporates a radical claim for the autonomy of natural philosophy. Bacon’s overall classification of knowledge is encyclopædic and comprehensive: Anything that even passes for knowledge is included and finds a niche in the overall schema. One

63 *Works* i.194/iv.87–8.

64 Note the issue is one of the autonomy of natural philosophy with respect to theology or a theologically driven metaphysics. This is quite different from the question of the relation between natural philosophy and religion generally. Moreover, in the development of seventeenth-century English natural philosophy, it comes to have a very close relationship with natural theology, but, by contrast with the Aristotelian–Scholastic conception, it is much closer to a relation between equals, considered as mutually supportive. The situation is different again from that which held in the nineteenth century, in the wake of the disputes over Darwinism, where the issue was not one of the autonomy of science, which was well-established, but one of determining the domain of competence of conflicting disciplines – science and theology.

65 There are innovations, one of which is the redrawing of the boundaries between civil and natural history, both of which Bacon treats as being based in the faculty of memory. In this he follows José de Acosta, *The Natural and Moral History of the Indies*, trans. Edward Grimston (London, 1604). This linking of civil and natural history formed the basis for much of the eighteenth-century ‘science of man’, especially in the Scottish Enlightenment: See Paul B. Wood, ‘The Science of Man’, in N. Jardine, J. A. Secord, and E. C. Spary, eds., *Cultures of Natural History* (Cambridge, 1996), 197–210.

thing that is potentially worrying about this approach, however, is that an extrinsic classification may be being imposed on topics which does not reflect their intrinsic relations. On the basis of the way in which Bacon treats the prolongation of life, for example, we might reasonably expect a close connection between natural history, inasmuch as it deals with the mechanical and experimental arts, natural philosophy, and that part of human philosophy which deals with the prolongation of life. Yet these come within fundamentally different divisions of knowledge: The first comes in the first division of human learning (history), the second and third within very different parts of the third division (philosophy). As a consequence, we may suspect that Bacon's classification actually obscures crucial relations between different enterprises, and that this results in large part from the unnecessarily comprehensive nature of his schema.

However, there was a more fundamental issue at stake, and whether natural philosophy is most usefully pursued within the constraints imposed by an encyclopædic understanding of knowledge is not really the question that occupies Bacon. Rather, establishing for natural philosophy a secure place within the whole body of learning is a way of securing the legitimacy of natural philosophy as an autonomous discipline. What the classification crucially reveals is not so much an awkward separation between natural history and natural philosophy, for example, but, above all, the independence of natural philosophy and natural history from theological concerns. His classification puts just about as much distance between them as is possible.

The utilitarian vindication of natural philosophy

One of the 'curses' that resulted from the Fall was aging and death. Adam was urged not to touch the forbidden fruit – 'neither shall you touch it lest you die' (Gen. 5.5) – which was generally taken to mean that he would have enjoyed immortality, had he not sinned. There was a view, shared by Milton, for example, that immortality was enjoyed by all living things in Eden, including plants,⁶⁶ and that the Fall was responsible for mortality generally – although the aging process seems to have taken some time to come into effect, Adam himself reputedly living until the age of 930.

Longevity was an issue where two sets of concerns central to Bacon's project met: the renewal of human dominion over nature, and the establishment of natural philosophy as an archetypically practical discipline. Both of these converge on the idea that natural philosophy exists primarily to benefit mankind. It is therefore unsurprising that Bacon gave

66 See Harrison, *Bible, Protestantism*, 213–15.

more thought to the question of increasing longevity than any other natural philosopher of the early-modern era, working out, from the mid-1610s onwards, a detailed account of the causes of aging and various suggestions as to how the process might be retarded and perhaps even stopped. It is above all in his treatment of longevity that the practical and utilitarian value of natural philosophy comes to light most clearly, and of all his substantive natural-philosophical projects, from natural history to cosmology, it is the one to which he seems to have devoted the greatest time during the last ten years of this life, writing two accounts of the aging process: *De Vijs Mortis* in the late 1610s, and *Historia Vitæ & Mortis* in the early 1620s.⁶⁷

Speculation about the aging process has been widespread since Parmenides, who maintained that aging is caused by diminution of warmth in the body. Many in the seventeenth century, especially Puritans (although the view can be traced back as far as Roger Bacon), believed that man had been created in the Garden of Eden without imperfections, and could have expected to live there forever; and though immortality may have been lost with the Fall, human beings had retained a residual capacity for longevity. The idea that the aging process might be retarded or checked is one which had attracted considerable interest in the seventeenth century. The great scientific utopias of the early-modern era – not just Bacon's, but those of Campanella, Andreae, and Comenius⁶⁸ – all raise the issue of prolonging life. As influential a figure as Descartes carried out experiments to inhibit the greying of hair and, nearly a century later, Boerhaave proposed a comprehensive mechanistic approach to the question.⁶⁹

Historia Vitæ & Mortis was designed as a contribution to the 'Great Instauration', which Bacon intended as a blueprint for the comprehensive reform of natural philosophy. It forms part of the third division, which was designed to comprise 'a natural and experimental history for the foundation of philosophy', and it is in fact by far the longest and most

67 *De Vijs Mortis*, whose full title in English is 'An Inquiry concerning the Ways of Death and Postponing of Old Age, and the Restoring of the Vital Powers', comprises an original text and extensive revisions, the former probably dating from the mid-1610s, and the latter possibly as late as 1619. The text, discovered only recently, has been reconstructed by Graham Rees and can be found, with copious notes, in vol. vi of *BW*. Bacon published an account of the same topic as *Historia Vitæ & Mortis* in 1623. The latter was explicitly designed for Part III of the 'Great Instauration', whereas it seems *De Vijs* was more likely intended for Part I of that project: See *BW* vi.xxxi-xxxv.

68 See Charles Webster, *The Great Instauration: Science, Medicine and Reform (1626-1660)* (London, 1975), 246-50.

69 Descartes provides no details of his experiments. Boerhaave is a little more forthcoming: See Thomas S. Hall, *Ideas of Life and Matter*, 2 vols. (Chicago, 1969), i.384.

comprehensive of the contributions to this division, an emphasis which is wholly appropriate, given Bacon's idea that natural philosophy must benefit mankind.

The investigation begins with an inquiry into which kinds of things are durable and which are not, and Bacon draws two conclusions. The first is that all bodies contain a hidden *spiritus* or pneumatic matter (*corpus pneumaticum*), which is responsible for all dissolution and consumption, so that, if these are to be prevented, the antidote lies in the retention of *spiritus*. The second is that there are two ways of retaining *spiritus*: by confinement, which is characteristic of hard things, and by voluntary detention, as it were, which is characteristic of oily things, which 'soothe' the *spiritus* and so prevent it being acted upon by the air. His discussion of plants leads him to concur with Aristotle's observation that animals come to full growth at an early stage and then cease growing, so that 'of necessity the juices of animals must soon grow old', whereas those of plants, which continue to put out new growth throughout their life, 'are always fresh and untouched by age'.⁷⁰ One of our principal aims in arresting the aging process must therefore be the understanding and prevention of desiccation, and on the basis of a review of thirty-one quite varied pieces of evidence, ranging from the effect of fire on metals to the preservation of grapes, Bacon concludes that the processes of desiccation and wasting away derives from three processes brought about by *spiritus*: the attenuation of moisture into *spiritus*, the escape of *spiritus* into the air, and the contraction of the larger parts of the body after the emission of *spiritus* (ii.119–21/v.231–3).

Bacon turns next to the longevity of animals, recording the reputed life spans of various animals, and asking to what the significant differences in longevity can be attributed. Birds, for example, tend to have a higher average life span than land animals, which Bacon puts down to their having 'more of the substance of the female than of the male, whence they have a less hot and fiery spirit' (ii.128–9/v.239). Diet is also important, since living bodies not only persist with a particular identity, as inanimate things do, but also repair their bodies, something crucially tied to the intake of nutrients, which distinguishes living from nonliving bodies (ii.108/v.220), and carnivores live longer than herbivores or graminivores. The type of protective covering with which the body is supplied is also crucial. Since *spiritus* is enclosed predominantly in the head, and since it absorbs and consumes the body, animals with proportionately smaller heads, such as birds, live the longest (ii.129–30/v.240).

⁷⁰ *Vit. & Mort.: Works* ii.112–14/v.224–6. Subsequent citations in this section to *Historia Vitæ & Mortis* will be given parenthetically in the text solely by *Works* volume and page.

At this point Bacon moves to his main concern, the length of human life, and he sets out in detail the available information on longevity, from biblical, classical, and more contemporary sources, citing many cases of people who had lived to over a hundred (ii.132–55/v.243–63). Contemporary medicine, Bacon complains, has devoted itself exclusively to the preservation of health and the cure of disease, almost completely ignoring the question of longevity. There are, however, medicines that stimulate the heart – cordials – which may also have the effect of prolonging life: potable gold (gold filings sprinkled in a drink such as wine is what Bacon recommends here), pearls, emerald, and jacinth taken in the form of fine powder, as well as frequent bleeding (ii.155–7/v.263–5).⁷¹

How, then, is longevity secured? There are three principal ways, Bacon tells us: prevention of consumption or wasting away, the perfection of the repair processes, which primarily involves dietary considerations, and the renovation of what is old, by softening and moistening the parts that have become hard and dry (ii.109–110/v.222). He is not prepared to advocate anything in this respect that interferes with the ‘offices and duties of life’: living in a cave, or exact regulation of diet so that it becomes an end in itself. Nor is he prepared to countenance the idea that there might be a quick remedy; we are ‘not to imagine that so great a work as the stopping and turning back of the powerful course of nature can be performed by a morning draught, or the use of some precious drug’ (ii.159–60/v.266–7). Moreover, he is concerned to point out the difference between things conducive to health and things conducive to longevity. Finally, he is realistic about the lack of experimental evidence for much of what he proposes, and the fact that a lot depends on individual temperament.

The first remedy for longevity, prevention of consumption or wasting away, requires four operations (ii.161–86/v.269–305). The first is the renewal of the *spiritus* in the body. Since the spirits are the agents by which all effects in the body are produced, something which Bacon assumes as common ground, they are the key to the aging process, and they must be transformed so that ‘they shall not drink and absorb, but only sip the juices of the body.’ For this they must be prevented from becoming excessive or irregular in their motion. In general, we must stop them becoming condensed, and this can be done either by ‘putting them to flight’, something best achieved by opium and opiates, but which can be achieved by other narcotics such as by coffee and tobacco; by cooling them, with cool air or by consuming food with nitre, which is ‘the only body found in the vegetable world which abounds with spirit and is yet cold’; by soothing, for which opium and nitre suffice; or by ‘quieting the

⁷¹ Bacon is very tentative here, condemning outright many similar remedies: *Works* ii.157–8/v.265–6.

violence of the spirits.⁷² Generally speaking, cooling the spirits is to be achieved by dietary means, avoiding hot herbs and spices and eating such things as young watercress and garlic. Reducing their quantity can be achieved by drinking water and following a frugal diet, but we must be careful in this respect not to do this to excess, so as 'not to neglect a seasonable use of sexual intercourse, lest the spirits grow too full.' We can restrain their motion through sleep, avoiding hard labour, and avoiding too much exercise. Finally, great joys, sensual impressions of joys, joys indulged, great fears, envy, and suppressed anger all shorten life, whereas cheerfulness, ruminations of joys in memory, grief and sadness when devoid of fear, anger indulged, and above all hope lengthen it. The second operation in this remedy is the exclusion of air, which 'preys upon the juices of the body and hastens its desiccation', and when it is excluded it 'detains the *spiritus* within, and turns it upon the harder parts of the body, which are thereby rendered soft and tender.' Life in caves, if somewhat impractical, helps in this respect, as does life on mountain-tops, where the air is clear and pure; but failing these, anointing the skin with oil is the most helpful remedy. The third operation is to make the blood less liable to be affected, for which it must be cooled, and Bacon recommends clysters (medicines injected into the rectum) and cool baths, and taking various ground precious metals and precious stones, or woods such as sandal, oak, and vine cooked in broths. Finally, the fourth operation is to make the juices of the body harder so that they are less easily affected by the action of *spiritus*, and moderate exercise and moderate diet offer the key here.

The second remedy for longevity, perfecting the repair of the body, also requires four operations (ii.186–98/v.293–305). The first is proper digestion and bowel movement, which depend primarily on proper diet. The second involves action upon the outer parts of the body so that it can digest properly, for which purpose various rubbings and exercises are recommended. The third is appropriate nutrition: Roast or baked food is to be preferred to boiled, meat should be beaten before it is cooked, and so on. The fourth is the assimilation of the nutrients by the body, which Bacon tells us happens principally during sleep and rest, and his only advice is that one keep warm during sleep.

Finally, the third remedy for longevity, the renovation of bodily decay, requires two operations (ii.198–203/v.305–10). The first is the softening of those bodily parts that have become dry: The remedy that Bacon recommends here is to rub the body with oils, bathe for two hours, then cover the body with a plaster of mastic, myrrh, gum-dragon, diapalma,

72 Nitre refers both to potassium nitrate (saltpetre) and to a supposed nitrous constituent of plants and air. There is a good discussion of 'aerial nitre' in Robert G. Frank, *Harvey and the Oxford Physiologists* (Berkeley, 1980), chap. 5.

and saffron, and to keep this on for at least twenty-four hours. The second is the purging of old juices and the supply of new ones, where the means of achieving this is dietary.

Historia Vitæ & Mortis finishes with a short discussion of what happens immediately before and after death, comparing death in human beings with that in other animals, and a short summary of differences between youth and old age (ii.203–26/v.311–35). Bacon is certainly not the only writer in the early-modern era to pursue the question of remedies promoting longevity – quite the contrary, it is difficult to find any natural philosopher wholly uninterested in the question – but, at least before Boerhaave, no one pursued the question in such detail and on such elaborate natural-philosophical foundations.⁷³ The natural-philosophical pursuit of life-prolonging remedies is not merely an application of fundamental principles to the biological realm, but is in some ways constitutive of the natural-philosophical programme: It is where natural philosophy proves its worth, where it proves it is the worthy successor to moral philosophy. Just as, for Renaissance thinkers, moral philosophy must not only show the nature of virtue but also make us more virtuous, so natural philosophy, for Bacon, must go beyond allowing us to understand nature, and enable us to shape it; and what better example of this could there be than overcoming the aging process?

73 A distinction must be made here between the search for longevity, which takes the form of a study of the aging process and attempts to retard this process by trying to discover what is lost in aging and how one might replenish this, and the search for the ‘philosopher’s stone’, which is supposed to secure immortality by chemical means, where these chemical means do not repair damage done by aging so much as transform the human being from the kind of thing that ages into the kind of thing that does not. The idea that death might be completely overcome by chemical means was not fully discarded in the seventeenth century. Boyle reported, if in a somewhat cryptic manner, in his ‘Of the Incalcescence of Quicksilver with Gold’ published in the *Philosophical Transactions* in 1676, that he had mastered the first stage of the creation of the philosopher’s stone, namely the production of ‘incalescent’ mercury, and in effect advertised for help in moving to the manufacture of the philosopher’s stone proper. Newton, no less, took this seriously, and on learning of Boyle’s death in 1692, pressed Locke, who had access to Boyle’s papers and chemicals, for details of the process and a specimen of the ‘red earth’ that Boyle had used, and indeed he may well have come close to poisoning himself trying to follow Boyle’s experiments. See Lisa Jardine, *Ingenious Pursuits: Building the Scientific Revolution* (London, 1999), 325–31; Lawrence M. Principe, *The Aspiring Adept: Robert Boyle and His Alchemical Quest* (Princeton, 1998), 155–80.

The shaping of the natural philosopher

The psychology of knowledge

In 1597, at the age of thirty-seven, Bacon published his first book, a slim octavo collection containing three works: a collection of ten brief English *Essayes*, the short Latin essay *Meditationes Sacrae*, and *Coulers of Good and Evill a Fragment*.¹ The term 'essay' literally means 'attempt' (Fr. *essai*), and essays were generally aphoristic and thought-provoking: They were not designed to survey a field in any detail. It was Montaigne who had made the essay form such a success in the early-modern era, but although there can be little doubt that Bacon would have read Montaigne by 1597, he does not mention him as a source. Also, there are significant differences between Montaigne's essays and those of Bacon. Whereas Montaigne is enticing, drawing the reader in, shifting from the personal to the general, from the serious to the capricious, Bacon's tone is didactic throughout. Montaigne aims at a broad audience, while Bacon seems to be writing for the court: The *Essayes* are much closer to Castiglione than Montaigne, both in genre and in tone.

The *Essayes* proper – which deal briefly with study, with speech ('discourse'), ceremonies, followers and friends, lawsuits, spending money, health, honour and reputation, political factions, and negotiation – are resolutely practical. The first, 'Of Studies', does, however, draw attention to two enduring themes in Bacon, namely, the superiority of the learned in making judgements, and the notion that the value of studies is to be tied to their usefulness. Moreover, the instruction that we must 'reade not to contradict, nor to belieue, but to waigh and consider'² is surely an implicit rebuke to Scholastic methods of teaching. The *Medi-*

1 *Essayes. Religious Meditations. Places of perswasion and disswasion, seene and allowed* (London, 1597). The text of the *Essayes* is given in *Works* vi.523–34, *Meditationes Sacrae* in *Works* vii.233–42 (with the 1598 English translation at 243–54), and *Coulers of Good and Evill a Fragment* in *Works* vii.75–92.

2 *Works* vi.525.

tationes Sacrae also touch on the related theme of the preconditions for learning. Drawing the moral 'Be as wise as Serpents, and innocent as Doves', Bacon writes:

To a man of perverse and corrupt judgement all instruction or persuasion is fruitless and contemptible which begins not with discovery and laying open of the distemper and ill complexion of the mind which is to be recured: as a plaster is unseasonably applied before the wound be searched. For men of corrupt understanding, that have lost all sound discerning of good and evil, come possessed with this prejudicate opinion, that they think all honesty and goodness proceedeth out of simplicity of manners, and a kind of want of experience and unacquaintance with the affairs of the world. (*Works* vii.234/245)³

The phrases 'simplicity of manners' and a 'want of experience and unacquaintance with the affairs of the world' indicates that Bacon's target is the zealots. It is striking here that he associates inexperience in worldly affairs with 'prejudicate opinion'. When one compares this approach to that of the other great reformer of knowledge, Descartes, the difference could not be more extreme. Descartes's strategy, at least at the most programmatic level, is to rid the mind of all preconceptions, whether warranted or not, so that he might build up knowledge from scratch on a secure basis. Bacon's approach, by contrast, is resolutely within the humanist tradition. There is no question of building up from scratch in this sense.

This notion that one must come to material well-prepared if one is to benefit from it is reinforced in the third part of the collection, entitled *Of Coulers of Good and Euill a Fragment*. The term 'colours' refers to general precepts of argument, or commonplaces, and the title page of the *Essayes* refers to it as 'places of persuasion and dissuasion'. The problem is that persuasive arguments about the nature of good and evil use both 'true and solid reasons' and 'colours, popularities and circumstances, which are of such force, as they sway the ordinary judgement either of a weak man, or of a wise man not fully and considerably attending and pondering the matter.'⁴ Does this mean that we should try and stick to the true and solid reasons and ignore the 'colours'? Such would be the response traditionally associated with the Stoics, whereby passions are simply false judgements, so we should seek to rid ourselves of them if we are to attain wisdom. This is not Bacon's response. Quite the contrary, as one would expect of someone raised on Cicero and Quintilian, he has a much more nuanced view on the nature and role of persuasion:

3 The English translation is from the 1598 reprint of the *Essayes*, and may well have had Bacon's sanction (see *ibid.* 229).

4 *Works* vii.77.

Besides their [i.e., the colours'] power to alter the nature of the subject in appearance, and so to lead to error, they are of no less use to quicken and strengthen the opinions and persuasions which are true: for reasons plainly delivered, and always after one manner, especially with fine and fastidious minds, enter but heavily and dully: whereas if they be varied and have more life and vigour put into them by these forms and insinuations, they cause a stronger apprehension, and many times suddenly win the mind to a resolution. (*Works* vii.77)

In other words, it is not just that rhetorical techniques of persuasion do not uniformly mislead; nor are they simply ornaments. Bacon is on strong ground here. Rhetoric engages something that logic does not: human psychology. Psychological theory is carried from Aristotle through to the early-modern period above all in the form of rhetorical theory.⁵ Rhetoric is, among other things, a theory about how to engage the emotions, and to further this end writers like Quintilian had developed detailed views about human psychology and how it might be affected.⁶ The aim is not to abandon techniques of persuasion, but to understand them better, and it is only on the basis of such a better understanding of these techniques that one will gain a better understanding of the arguments they are used to project:

to make a true and safe judgement, nothing can be of greater use and defence to the mind, than the discovering and reprehension of these colours, shewing in what cases they hold, and in what they deceive: which as it cannot be done, but out of a very universal knowledge of the nature of things, so being performed, it so cleareth man's judgement and election, as it is the less apt to slide into any error. (*Works* vii.77)

There is a psychological dimension to knowledge here, so that questions of presentation of knowledge are not only recognised to be important, but have to be understood, where such an understanding is not supplementary to epistemology but actually part of epistemology. There is nothing new in this at one level, for it is simply part of a long tradition which begins in earnest with the Roman rhetoricians; but although it borrows from Greek writers, it is rather different from the approach to epistemological questions that we find in the classical Greek philosophers, and, to a lesser extent, in the Hellenistic philosophers. When one

5 The *De Anima* commentaries dealt with Aristotelian psychology, of course, but they were directed at a specialised audience, and it seems that medical students were their main beneficiaries: See Katharine Park and Eckhard Kessler, 'The Concept of Psychology', in Charles B. Schmitt, Quentin Skinner, and Eckhard Kessler, eds., *The Cambridge History of Renaissance Philosophy* (Cambridge, 1988), 455–63.

6 See, for example, Kathy Eden, *Poetic and Legal Fiction in the Aristotelian Tradition* (Princeton, 1986).

thinks of Bacon's general project in this context, it becomes clear that there is something novel here; for natural philosophy had generally been the preserve of Greek philosophy, and had been pursued in a similar way by Scholastic philosophers. The Roman tradition, with the exception of Lucretius, had generally speaking not concerned itself with speculative natural-philosophical questions, dealing instead with practical moral, political, and legal issues. In thinking of persuasion in terms of a psychological theory, in thinking of psychological theory as part of epistemology, and in thinking of epistemology as being directed primarily towards natural philosophy, Bacon can provide himself with some of the resources to start thinking through natural philosophy not as a speculative but as a practical discipline. For although the *Colours* starts off with moral questions, its treatment is in fact wholly general, and it ends, in the tenth section, for example, with a criticism of astrologers.⁷

This psychology-of-knowledge approach to epistemology is developed further in a roughly contemporaneous piece, the *Letter and Discourse to Sir Henry Saville touching Helps for the Intellectual Powers*.⁸ Here a new ingredient comes into the picture, however, namely that of transforming one's faculties. Bacon's concern is with the will and the intellect, and his account of how the former might be redirected is of particular interest from the perspective of his subsequent attempts to shape natural philosophers:

As to the will of man, it is that which is most maniable and obedient; as that which admitteth most medicines to cure and alter it. The most sovereign of all is Religion, which is able to change and transform it in the deepest and most inward inclinations and motions. And next to that is Opinion and Apprehension; whether it be infused by tradition and institution, or wrought by disputation and persuasion. And the third is example, which transformeth the will of man into the similitude of that which is much observant and familiar towards it. And the fourth is, when one affection is healed and corrected by another; as when cowardice is remedied by shame and dishonour, or sluggishness and backwardness by indignation and emulation; and so of the like. And lastly, when all these means, or any of them, have new framed or formed human will, then doth custom and habit corroborate and confirm all the rest. Therefore it is no marvel though this faculty of mind of will and election, which inclineth affection and appetite, being but the inceptions and rudiments of will, may be so well governed and managed, because it admitteth access to so divers remedies to be applied to it and to work upon it. The effects whereof are so many and so known as require no enumeration; but generally they do issue, as medicines do, into two kinds of cures; whereof the one is a just or true cure, and the other is called palliation. For either the labour and intention is to reform the affections really and truly, restraining

⁷ *Works* vii.91.

⁸ On dating, see *Works* vii.95.

them if they be too violent, and raising them if they be too soft or weak, or else it is to cover them: of the former sort whereof the examples are plentiful in the schools of philosophers, and in all other institutions of moral virtue; and of the other sort the examples are more plentiful in the courts of princes, and in all politic traffic. (*Works* vii.100–1)

When he turns next to intellectual powers, Bacon tells us that these ‘have fewer means to work upon them than the will’, and that the most important and most effective means is ‘exercise’, for example, in composing, remembering, arguing, and even ridiculing (‘the exercise of buffons, to draw all things to conceits ridiculous’).⁹ The notion of exercises for the intellect is suggestive of the traditional ‘spiritual’ exercises of philosophers in the Hellenistic, Roman, and Neoplatonic traditions, and which were part of the shaping of a philosophical persona.¹⁰ And the connection between philosophical doctrine and the persona of its advocate is an intimate one for Bacon.

The poverty of antiquity

In 1602, Bacon wrote a short draft of an unfinished work, *Temporis Partus Masculus*¹¹ – the ‘masculine birth of time’ – in which the case for a new start in philosophy is made via a polemical attack on earlier thinkers. *Temporis Partus Masculus* is set in the form of a lesson by a master to someone he addresses as ‘my son’, and its pedagogic setting suggests a continuation of the themes in the *Letter and Discourse to Sir Henry Saville*. The central theme is the legitimacy of knowledge, and the term *legitimus* constantly recurs. The birth of time is ‘masculine’ because its father is known, and hence legitimate. But why the birth of time, one may ask, and not, say, the birth of knowledge? In *Novum Organum*, Bacon tells us that ‘truth is rightly called the daughter of time, not the daughter of au-

9 *Works* vii.101.

10 See Pierre Hadot, *Philosophy as a Way of Life* (Oxford, 1995).

11 It is possible that this work is itself a redrafting of some earlier material, for, as I have already indicated, in a letter of 1625 Bacon refers to a writing, no longer extant, which he dates to around forty years earlier, entitled *Temporis Partus Maximus* – the greatest/most noble birth of time. Fulton H. Anderson, *The Philosophy of Francis Bacon* (New York, 1971), makes a strong case that the work is no later than 1603, and Benjamin Farrington, *The Philosophy of Francis Bacon: An Essay on Its Development from 1603 to 1609 with New Translations of Fundamental Texts* (Chicago, 1964) [hereafter cited as *PFB*], p. 57, points out that it refers to the death of Severinus, which occurred in 1602. The fragment contains two chapters of the first part of a projected three-part project, the parts dealing respectively with ‘polishing and directing the mind’, ‘the light of nature or formula of interpretation’, and ‘nature illuminated, or the truth of things.’

thority.¹² I take this to mean that knowledge is built up cumulatively, and is not something that can be grasped by a single philosopher, no matter how great, in isolation. If this is a correct reading, the upshot of the title is that it is cumulative effort that produces truth, so long as the process is begun in a legitimate manner, where *legitimus* has connotations of what is lawful and methodical.

In the first of the two short chapters, Bacon remarks on the shortcomings of knowledge and instruction in his day. Such instruction imparts figments of the brain, shadows thrown by words, science and religion mixed in together, or a few misleading commonplace observations. Bacon's aim, by contrast, is to explore the state of nature and the state of the human mind, and by so doing 'to stretch the deplorably narrow limits of man's dominion over the universe to their promised bounds.' The obstacles to this lie primarily in our own minds: 'all the approaches and entrances to men's minds are beset and blocked by the most obscure idols, idols deeply implanted and, as it were, burned in'. The solution is to find a new method for 'quiet entry into minds so choked and overgrown.' Some degree of subtlety is necessary, however, for 'frenzied men are exacerbated by violent opposition but may be beguiled by art.' Consequently, what we need is a method which is both mild and affords no occasion for error, which has an inherent plausibility and will 'stand up against the ravages of time, so that the tradition of science may mature and spread like some lively vigorous vine.'¹³

The weeding that is the subject of the second chapter, however, could not be described as 'mild' (*innocens*). It opens with the statement that we must clear philosophasters, or philosophical quacks, out of our path. These quacks include the masters themselves – Plato, Aristotle, Hippocrates, Galen – as well as their disciples from antiquity to the present. Aristotle, for whom Bacon reserves some of his strongest criticism, is 'that worst of sophists, stupified by his own unprofitable subtlety', who, just as a little truth began to emerge, immediately sought to fetter our minds, composing a manual of madness that made us slaves of words, covering over the useful observations that had been made with 'spiders' webs which he would have us accept as causal bonds'. Plato's philosophy, on the other hand, 'was but scraps of borrowed information polished and strung together.' Plato at least had the merit of supplying conversation for men of culture, but his notion that 'truth was a native inhabitant of the mind and need not come in from outside to take up its abode there' turned men's minds away from observation, instead turning their eyes inwards towards their own 'blind and confused idols',

12 Works i.190.

13 See Works iii.529/PFB, 62.

under the name of contemplative philosophy. Galen is dismissed as narrow-minded, deserting the path of experience and 'spinning idle theories of causation',¹⁴ and Hippocrates had nothing to offer but 'a few sophisms sheltered from correction by their curt ambiguity, or a few peasants' remedies made to sound imposing'.¹⁵

The followers and critics of these ancient masters are criticised even more fulsomely.¹⁶ Cardano 'is at variance with the facts and with himself'; Ramus is a 'pestilent book worm'; Cicero and Seneca were 'satisfied with a popular and easily acquired knowledge of nature'; Fernel is among the worst and most contemptible of worthless modern physicians, aiming to win approbation by means of the eloquence and orderliness of his writings, while confining the whole of medicine within narrow hair-splitting bounds; Agrippa is a 'trivial bufoon'. Paracelsus is compared unfavourably to Epicurus, who, 'like a man dropping off to sleep or with his attention fixed on something else, utters words at random', whereas Paracelsus cannot even manage that: His utterances 'are too stupid to be random.' Alchemists are 'like the dainty lad who found a plank on the beach and was seized with the desire to build a ship, so these charcoal-burners on the foundation of a handful of experiments on distillation presumed to found a philosophy.'

Among more recent thinkers, Roger Bacon and Peter Severinus are singled out for praise, the former for his subtle applications of mechanics, the latter for his ability to turn Paracelsus's 'detestable falsehoods' into 'delectable fables'.¹⁷ Among the ancients, the 'number philosophy'

14 This was not untypical of the treatment that Galen was to receive in the seventeenth and eighteenth centuries, and its thrust follows Bacon. Compare, for example, Mandeville, *A Treatise of the Hypochondriack and Hysterick Diseases* (London, 1730), 63-4:

Galen himself, a Man of very great Sense, and no less Pride, having entertain'd the Ambition of raising himself above any of his Contemporaries, foresaw, that to exceed the most skillful of them in real Knowledge, would be a very difficult task, if not impossible, and at best tedious work of endless Labour: He was well acquainted with the state of Physick and the Palate of his Garrulous Age, and found that nothing would sooner or easier establish his Reputation, than his Wit: Accordingly he left the Observations to them that liked them, and fell a writing fine Language in a florid style. He told the World that Physick was a rational Art, that they were Beetle-headed Fellows, that could not make it intelligible, and presently gives them Reasons, such as they were, for every individual thing he could think on. This took wonderfully with the People of those Days. Seeing his Reasons so well accepted, he writ on and stuck at nothing. . . . This was the beginning of People's reasoning about Physick, from Speculation and Probability; and that the cause of all the Hypotheses we have had since, the best of which will be always defective and full of Error.

15 See *Works* iii.529-35/PFB, 63-8.

16 See *Works* iii.530-4/PFB, 63-7.

17 *Works* iii.533-4/PFB, 67.

of Pythagoras is praised, as is Heraclitus' claim that it is a mistake to seek knowledge in the private world of each person instead of in the common world; Epicurus on the doctrine of final causes is worth listening to, and Pyrrho and the Academics at least offer entertainment.¹⁸ The only unqualified praise, however, is for Democritus, who 'attributed to nature immense variety and infinite succession, thus setting himself apart from all other philosophers, who were prisoners of their times and slaves of fashion.'¹⁹ Indeed, Bacon remarks, 'this was a genuine contribution to philosophy', and if it is not the only such genuine contribution, it is the only one mentioned. By his stand, we are told, Democritus 'destroyed two falsehoods by knocking their heads together and opened up a middle path to truth.'²⁰

The extreme polemical edge of *Temporis Partus Masculus* makes it a distinctive work, although one can find precedents, among them those texts that Mersenne picked out as virulently anti-Aristotelian in 1625, in his *La Vérité des sciences*: He includes the works of Sebastian Basso, David Gorlaeus, Jacques Charpentier, and Pierre Olivi,²¹ and three authors with whose works Bacon may have been familiar. The first is Nicholas Hill, whose *Philosophia Epicurea* (1601) is an eclectic mix of Democritus, Bruno, Hermes Trismegistus, Gilbert, and others, including Aristotle, although the thrust of the work is anti-Aristotelian.²² The second is Jean Bodin, whose *Universae Naturae Theatrum* (1596), for example, contains around 160 attacks on Aristotle, and had a wide circulation in the seventeenth century.²³ However, the text that stands out most clearly in this respect is the *Discussiones Peripateticae* of Francesco Patrizi, which first

18 Works iii.537/PFB, 71.

19 Ibid.

20 Ibid. The image of Democritus that came down to Bacon was somewhat different from how we now see him. As Paolo Rossi points out in his *Francis Bacon: From Magic to Science* (Chicago, 1968), 245 n. 57, he was treated by Pliny and by Columella, the first-century author of *De re rustica*, as a 'magician', and Seneca tells us how he was able to colour glass and metals, modify ivory, and turn sand into precious stones. In other words, he was regarded as a person of great practical skills. This doubtless played a very significant role in Bacon's appraisal of him.

21 Marin Mersenne, *La Vérité des sciences* (Paris, 1625), 109–10. I am assuming that the reference to 'Oliue' is to the thirteenth-century anti-Aristotelian theologian Pierre Olivi, despite the fact that he is much earlier than the others mentioned.

22 See Jean Jacquot, 'Harriot, Hill, Warner and the New Philosophy', in John W. Shirley, ed., *Thomas Harriot: Renaissance Scientist* (Oxford, 1974), 107–28.

23 See Ann Blair, *The Theater of Nature: Jean Bodin and Renaissance Science* (Princeton, 1997).

appeared in 1571.²⁴ Patrizi, a staunch Platonist, set out not just to refute Aristotle's doctrines, but to discredit him personally, and to show that his followers are simply slavish imitators; to show that his personal life was dissolute, that he was disloyal to Plato, and hostile to his patron Alexander. It is interesting in this respect that Joseph Glanville, one of the principal apologists for the Royal Society in the Restoration, should associate Bacon and Patrizi, seeing them as being engaged in the same kind of project:

And that Aristotle dealt so *invidiously* with the Philosophers that were before him, will not need much proof to one, that is but indifferently acquainted with his writings. The great Lord Bacon hath particularly charged him with this unworthiness in his excellent *Advancement of Learning*, wherein he says, that 'Aristotle as though he had been of the race of *Ottomans*, thought he could not reign, except that the first thing he did, he kill'd all his Brethren.' And elsewhere in the same Discourse 'I cannot a little marvel at the Philosopher *Aristotle*, that proceeded in such a spirit of difference and contradiction to all *Antiquity*, undertaking not only to frame new words of Science at pleasure, but to confound and extinguish all the *antient Wisdom*, insomuch that he never names any *Antient Author*, but to confute or reprove him' consonant whereunto are the observations of *Patricius* that he carpes at the *Antients* by name in more than 250 places, and without name in more than 1000. [H]e reprehends 46 *Philosophers* of worth, besides *Poets* and *Rhetoricians*, and most of all spent his spleen upon his excellent and venerable Master *Plato*, whom in above 60 places by name he hath contradicted. And as *Plato* opposed all the *Sophisters*, and but two *Philosophers*, viz. *Anaxagoras* and *Heraclitus*; so *Aristotle* that he might be opposite to him in, *this* also, oppos'd all the *Philosophers*, and but two *Sophisters* viz, *Protagoras* and *Gorgias*. Yea, and not only assaulted them with his arguments, but *persecuted* them by his *reproaches*, calling the *Philosophy of Empedocles*, and all the *Antients Stuttering*; *Xenocrates*, and *Melissus, Rusticks*; *Anaxagoras, simple* and *inconsiderate*; yea, and all of them in a heap, as *Patricius* testifies, gross *Ignorants, Fools* and *Madmen*.²⁵

24 The work was the first installment of *Discussionum Peripateticarum Tomi Quatuor* (Basel, 1581). See the account of Patrizi in Brian P. Copenhaver and Charles B. Schmitt, *Renaissance Philosophy* (Oxford, 1992), 187–95.

25 Joseph Glanville, *A Letter to a Friend Concerning Aristotle*, appended to *Scire/fi Tuum Nihil Est; or, The Author's Defence of the Vanity of Dogmatizing* (London, 1665), 84–5. The quotation from Bacon given here was sufficiently influential to stand at the beginning of the first (1660) edition of Stanley's *History of Philosophy*, but it is displaced to the middle of the book in the second edition as material on earlier philosophers is added at the front: Thomas Stanley, *The History of Philosophy: containing the Lives, Opinions, Actions and Discourses of the Philosophers of every Sect*, 2nd ed., 3 vols. (London, 1687).

Yet *Temporis Partus Masculus* does have more to it than abuse of the ancients and their followers, and it has more to it than the diatribes of Patrizi and Glanville. Although destructive of virtually the whole philosophical tradition, Bacon's 'weeding' has a positive purpose. 'You will admire beneath the veil of abuse', he tells us, 'the spirit that has animated my attack.'²⁶

The interpretation of the past

If we do indeed strip away the veil of abuse, we find that Bacon is advocating a novel and powerful doctrine. The characterisation of Democritus as someone who, unlike all other ancient philosophers, was not a prisoner of his times, points in the direction of a contextualisation, a historicisation, of knowledge. The idea that the times or culture that a person lives in can be invoked to explain their thought and behaviour was not completely unknown – the Greeks had, after all, characterised the 'barbarians' in such a fashion – but its systematic use was very rare. When Louis Le Roy, in arguing for the superiority of the modern era over classical Greece and Rome in his *De la vicissitude ou variété des choses en l'univers* (1575), used the case of (American) Indians to show that all primitive societies are uncivilised,²⁷ he was advancing a very radical thesis, not just in terms of the particular comparison, which was of course provocative, but in the very fact of contextualising or historicising a society like Athens or Rome. This importance of his equation of 'early' and 'primitive' lies less in what it asserts than in what it denies, and paramount in what it denies is the existence of a 'Golden Age' which provides a standard by which all later achievements are to be judged, yet to which they can never attain.

In one sense, Golden Age conceptions had themselves historicised or contextualised classical thought, in that they had seen Plato, Aristotle, Cicero, Seneca, and so on as figures who were representative of a particular time and culture in which things were possible which were no longer possible, and – this is the historicist part – they had seen cultures largely in terms of the time at which that culture existed, that is, in terms of a stage in the historical process. The new historicising tendency of sixteenth-century French humanists such as Bodin, Le Roy, and La Popelinière inverts this conception. It accepts these figures as being representative of a particular time and culture, and accepts the importance of their being at a particular stage in a historical process, but offers a completely different assessment of this process and the cultures it gener-

²⁶ Works iii.536–7/PFB, 70.

²⁷ Loys Le Roy, *De la vicissitude ou variété des choses en l'univers*, ed. Philippe Desan (Paris, 1988), Book 10.

ates. Time is now modelled not on some notion of Golden Age followed by a decline, but rather on growth from infancy to maturity and wisdom, so that the cultures of later times supersede those of earlier ones.

We can find this conception in English writers such as Gilbert,²⁸ and it is indeed such a conception that lies behind Bacon's defence of natural philosophy in the *Redargutio Philosophiarum* of 1608. In pursuing his discussion of the philosophers of antiquity, he says he is 'holding to [his] rule of not entering into controversy on points of doctrine, but to judge by signs'.²⁹ It is now 'signs', that is, the distinctive characteristics of a doctrine that enable us to evaluate its content, or, more generally, the distinctive characteristics of an age than enable us to evaluate the cultural products of that age, rather than the content of particular theories or doctrines, that guides Bacon's interpretation of the philosophers of antiquity.

He argues first that we should draw conclusions from 'external signs', that is, from the culture and time in which classical learning was produced. In respect of the first sign, he demands of those who proudly say that their learning derives from the Greeks that they ask themselves what sort of people the Greeks were. They were, he tells us, a nation 'always mentally precipitate, and didactic by habit'.³⁰ They chatter and argue, without ever producing anything. In respect of the second sign, he asks about the character of the age in which philosophy was born. It was one in which its people were only one degree removed from fables, with little historical knowledge or knowledge of other regions of the Earth – all northern peoples were referred to as Scythians and all western ones Celts without distinction, for example – and it lacked both a respect for earlier times and the wealth characteristic of modern times. The modern era, by contrast, has the benefit of two thousand years of history behind it, and has explored two-thirds of the globe.

Next he asks about the classical philosophers themselves. There are, he tells us, three classes of philosopher.³¹ First, there are the Sophists, who claimed to know everything and travelled around teaching for a fee. Second, there are those philosophers who, having a more exalted sense of their own importance, opened schools which taught a fixed system of beliefs, in which category Bacon includes Plato, Aristotle, Zeno (the Stoic), and Epicurus. Third, there were those who devoted them-

28 William Gilbert, *De Mundo Nostro Sublunari Philosophia Nova* (Amsterdam, 1651), 240. This work was not published in Gilbert's lifetime, and the edition was based on a manuscript in Bacon's library. On its provenance, see Susanne Kelly, *The De Mundo of William Gilbert* (Amsterdam, 1965).

29 Works iii.566/PFB, 112.

30 Works iii.563/PFB, 109.

31 Works iii.565/PFB, 111.

selves to the search for truth and the study of nature without fuss, without charging fees, and without setting up a school, such as Empedocles, Heraclitus, Democritus, Anaxagoras, and Parmenides.³²

Regarding philosophers of the second category as no better than those of the first, he proceeds to look at individuals, namely Plato and Aristotle, not entering into controversy on points of doctrine but judging them by signs.³³ What follows is a reflection on the personalities of Aristotle and Plato, in effect a reflection on their personal worth. In the case of Aristotle, the exercise could be mistaken for one in character assassination: Aristotle was, we are told, impatient, intolerant, ingenious in raising objections, perpetually concerned to contradict, hostile to and contemptuous of earlier thinkers, and purposely obscure. We need to ask what the point of these personal criticisms is. It is not as if Bacon does not have specific objections to the content of Aristotle's philosophy. He mentions some of the major points on which he disagrees with Aristotle here in *Redargutio Philosophiarum*: Aristotle mistakenly constructs the world from categories, and no less mistakenly deals with the distinctions between matter and void, and rarity and density, in terms of a distinction between act and potency. The personal attack on Aristotle seems both unnecessary to make his point, and counterproductive.

But I think that to see matters thus is to miss Bacon's thrust. The personal criticism is not an added extra: It is integral to Bacon's point. He explicitly tells us he is going to judge not by content of particular doctrines but by signs. Why, then, is the personal criticism so central to what he wants to do? The answer is that the natural philosopher is not simply someone with a particular expertise for Bacon, but someone with a particular kind of standing, a quasi-moral standing, which results from the replacement of the idea of the sage as a moral philosopher by the idea of the sage as a natural philosopher. We expect the moral philosopher to act in a particular way, like a sage, and this is an indication of the worth of his moral philosophy. The shift from moral philosopher to nat-

32 Bacon's characterisations here do not match our modern understanding. The Academy and Lyceum did not only not follow Plato and Aristotle blindly but offered very heterodox positions – in the case of the Academy, a series of different heterodox positions ranging from the view that the Forms were numbers to Pyrrhonism. Moreover, several Presocratic philosophers did found schools, Democritus among them. Finally, at least since the beginning of the twentieth century, the Sophists have received a more sympathetic reading than that offered in Plato. Although Farrington (*PFB*, 111 n. 1) is surely right to point out that Bacon was a pioneer in research into the Presocratics, his advocacy of them may owe much to Patrizi. See, in particular, Patrizi's praise of the Presocratics over Socrates in his *Discussionum Peripateticarum tomus Quattuor*, 369–74.

33 *Works* iii.566/*PFB*, 112.

ural philosopher as the paradigmatic sage means that the natural philosopher now takes on this quality. The worth of a natural philosophy is reflected in its practitioners, just as that of a moral philosophy is reflected in – or, perhaps, one should say embodied in – its practitioners.

In his discussion of moral philosophy in Book 2 of the *Advancement of Learning*, Bacon remarks on the various ways in which reason can be affected:

For we see Reason is disturbed in the administration thereof by three means; by Illaqueation or Sophism, which pertains to Logic; by Imagination or Impression, which pertains to Rhetoric; and by Passion or Affection, which pertains to Morality. And as in negotiation with others men are wrought by cunning, by importunity, and by vehemency; so in this negotiation with ourselves men are undermined by Inconsequences, solicited and importuned by Impressions or Observations, and transported by Passions. Neither is the nature of man so unfortunately built, as that these powers and arts should have the force to disturb reason, and not to establish and advance it: for the end of Logic is to teach a form of argument to secure reason, and not to entrap it; the end of Morality is to procure the affections to obey reason, and not to invade it; the end of Rhetoric is to fill the imagination to second reason, and not to oppress it: for these abuses of arts come in but *ex obliquo*, for caution. (*Works* iii.409–10)

The ultimate aim of moral philosophy, in Bacon's view, is to get people to behave morally; to discourse on the nature of the good, or to dispute whether 'moral virtues are in the mind of man by habit and not by nature', will not secure this end in their own right. What moral philosophy does not provide, and what needs to be provided, are the means of educating the mind so that it might aspire to and attain what is good:

The main and primitive division of moral knowledge seemeth to be into the Exemplar or Platform of Good, and the Regimen or Culture of the Mind; the one describing the nature of good, the other prescribing rules how to subdue, apply, and accommodate the will of man thereunto. (*Ibid.*: *Works* iii.419)

The first question, on the nature of the good, is divided into discussions of the various kinds of 'good's, and the various degrees of good.³⁴ We can distinguish something that is good in itself, for example, from something that is good as part of a greater whole, and the latter should have priority over the former: '[T]he conservation of duty to the public ought to be much more precious than the conservation of life and being.' It is on this basis that Bacon rejects Aristotle's claims for the value of the contemplative life over the active life, for all the arguments Aristotle gives for the contemplative life 'are private, and respecting the pleasure and

34 *Adv. Learn.* II: *Works* iii.421.

dignity of man's self', where of course the contemplative life is pre-eminent; and Bacon gives examples of the social harm that can come from ignoring civil life and using one's own happiness as a criterion. On the question of the relative merits of active and passive good – whether to propagate actively or to conserve – Bacon comes down firmly on the side of the former.³⁵ On the question of how to inculcate morality,³⁶ Bacon refers to 'the Culture and Regimen of the Mind.' He quotes Aristotle's remark that we want to know what virtue is and how to be virtuous – they are part of the same package, as it were; but he also points to Cicero's praise of Cato the Younger, who took up philosophy not that he might dispute like a philosopher, but that he might live like one. It is not just the parallel between the moral life and the philosophical life that is of interest here, but the fact that there is a particular persona associated with morality and with philosophy: It is not simply a question of having a particular expertise. What we must understand from the outset is what is within our power and what is not. We are limited in what we can do by the nature of the mind, and we need to 'set down sound and true distributions and descriptions of the several characters and tempers of men's natures and dispositions, specially having regard to those differences which are most radical in being the fountains and causes of the rest, or most frequent in concurrence or comixture.' In understanding these, we are discovering 'the divers complexions and constitutions' of the mind, but we also need to discover 'secondly, the diseases, and lastly the cures.' The 'diseases' are the 'perturbations and distempers of the affections' that disturb the mind. The cure consists in setting before oneself 'honest and good ends', and being 'resolute, constant, and true unto them'. The diseases and cure here have an importance that goes far beyond the moral realm, however, and Bacon's detailed account of the nature of the diseases and the regimen required for their cure is developed not in the context of moral philosophy, but in that of natural philosophy.

External impediments and the historicisation of knowledge

The *Redargutio* is a particularly important text for two reasons. First, it uses a contextualisation or historicisation of knowledge to legitimate the pursuit of natural philosophy in the modern era. Using an evolutionary conception of societies and their intellectual cultures, Bacon is able to argue that we would naturally expect natural philosophy to find better conditions for its nurturing in a culture which had reached maturity,

35 Ibid.: *Works* iii.424–8.

36 Ibid.: *Works* iii.432–42.

rather than in one in which society was still in its childhood. In other words, he is able to argue that what is possible in the modern era far outstrips anything that was possible in antiquity without even making a comparative assessment of their achievements, because the point depends on what it is possible to achieve in particular cultures, not on what has actually been achieved, although he does, of course, have independent criticisms of classical society in the latter respect. Second, the argument of the *Redargutio*, as I have indicated, highlights the often elusive connection between the persona of the natural philosopher and the value of natural philosophy. In grasping this, we can appreciate that what looks like personal abuse is in fact something much more complex. For what is ultimately at issue is the question of the standing of philosophy itself in an age when, as Bacon sees it, philosophy provides us with the means of understanding and controlling nature, 'the great instauration of the dominion of man over the universe' – something lost at the Fall and now finally possible again. Bacon is concerned with nothing less than a new era in human existence, the key to which lies in the natural philosopher; or, rather, it lies in a new kind of natural philosopher, whom Bacon hopes to mould. Before this can take place, however, the various impediments to the proper pursuit of natural philosophy need to be identified, and Bacon's first distinction in this respect is between external and internal impediments.

The external impediments to knowledge are those external conditions that have hindered the fostering and progress of knowledge. They are 'external' in the sense that they are neither something generated internally in the discipline, nor something psychological – the latter being, generally speaking, what Bacon is concerned with under the heading of 'internal' impediments. By identifying just what conditions hindered knowledge in antiquity, Bacon hopes to be able to spell out what institutional conditions are best for the pursuit of natural philosophy in the modern era. The internal impediments mirror these concerns at the psychological level, and the aim is to identify the psychological features of the mind which hinder the progress and fostering of knowledge. Bacon's account of the external impediments depends to a significant extent on his ability to historicise knowledge, whereas it is a *sine qua non* of his account of the internal impediments that he be able to psychologise it.

Although both external and internal impediments are mentioned early in Bacon's writings, the latter, the 'Idols of the mind', are not developed until the works of the 1620s, *Novum Organum* and *De Augmentis*, whereas external impediments are set out as early as the *Valerius Terminus* of 1603. In this relatively early work, he tries, by identifying the impediments that have obstructed the development of knowledge, to set out what 'external' conditions have hindered its fostering and pro-

gress.³⁷ He begins by spelling out the reasons why the level of achievement in natural philosophy and learning more generally was low in antiquity. In remote antiquity, lack of navigation and commerce meant that nations looked inwards: The range of phenomena studied was necessarily very localised, and researchers were isolated from one another and unable to exchange information or build upon one another's work. Moreover, there is a great difference in the manner of progress of mechanical arts, on the one hand, and theoretical or conceptual sciences on the other. The mechanical arts – the examples he gives are painting, artillery, and sailing – begin slowly and hesitantly but are gradually improved and refined, whereas the natural philosophy of Plato, Democritus, Aristotle, and Hippocrates develops quite differently. Here the beginnings are spectacular, but subsequent development is merely one of degeneration: 'In the former many wits and industries contributed in one: In the latter many men's wits spent to deprave the wit of one.' The problems arise from the fact that the 'sciences of conceit', unlike the mechanical arts, are taught in a way that aims at establishing the credibility and worth of the doctrines concerned, rather than in a way that opens them up to analysis and criticism. The point seems straightforward, but it is far from clear in what respect the 'sciences of conceit' avoid analysis and criticism. After all, the adversarial method which Bacon has criticised as being unsuitable to the pursuit of knowledge does little else but analyse and criticise: Indeed, that seems to be precisely why it gets us nowhere. Of course, this analysis and criticism may be applied exclusively to the doctrines of others, not to one's own doctrines, but the net effect is the same: the analysis and criticism of all doctrines. What Bacon seems to have in mind, however, is the contrast between destructive and constructive analysis and criticism, the former resulting in an exclusively interpretative and defensive approach, with a corresponding lack of innovation:

Then men begin to aspire to the second prizes; to be a profound interpreter and commenter, to be a sharp champion and defender, to be a methodical compounder and abridger. And this is the unfortunate succession of wits which the world hath yet had, whereby the patrimony of all knowledge goeth not on husbanded or improved, but wasted and decayed. (iii.226–7)

He goes on to point out that we cannot assume that the truest doctrines will be those that prevail among the population generally, and indeed perhaps we can be sure that the truest doctrines will never prevail, identifying the particular popular opinions, and the truer doctrine they have displaced, in the case of natural philosophy:

³⁷ Works iii.225–7. Subsequent citations in this section to *Valerius Terminus* will be given parenthetically in the text solely by *Works* volume and page.

[T]here is no great doubt but he that did put the beginnings of things to be *solid, void, and motion to the centre*, was in better earnest than he that put *matter, form, and shift*; or he that put the *mind, motion, and matter*. For no man shall enter into inquisition of nature, but shall pass by that opinion of Democritus, whereas he shall never come near the other two opinions, but leave them aloof for the schools and table-talk. Yet those of Aristotle and Plato, because they be both agreeable to popular sense, and the one was uttered with subtilty and the spirit of contradiction, and the other with a stile of ornament and majesty, did hold out, and the other gave place. (iii.227–8)

It is of interest here that, on a number of occasions, questions which look epistemological turn out to be issues of political organisation. So, for example, Bacon is concerned that particular parts of knowledge become isolated from what he calls 'the root and stock of universal knowledge', that is, that particular results lose contact with the discipline as a whole and, as a result, one loses a sense of the systematic connections between the parts of knowledge, connections which are often highly revelatory. The remedy for this lies in what might be termed the political organisation of knowledge, and he introduces an analogy with Spanish colonial rule, maintaining that we are led 'to an administration of knowledge in some such order and policy as the king of Spain in regard of his great dominions useth the state: who though he hath particular councils for several countries and affairs, yet hath one council of State or last resort, that receiveth the advertisements and certificates from all the rest' (iii.231). Similarly, when he looks at the errors arising from a failure to consider the ends of knowledge properly, so that one proceeds from common example or common opinion (iii.232), we should not take this as an exhortation for everyone to work out his own aims, so much as further demonstration of the need for a centralised authority to conceive the appropriate ends of inquiry. And when he calls for an 'inventory, or an enumeration and view of inventions already discovered and in use', this might seem the kind of thing that a single person could do; but Bacon has something more ambitious and labour-intensive in mind, something that may require a centrally directed and large-scale form of organisation, as is evident from how he characterises this project:

The plainest method and most directly pertinent to this intention, will be to make distribution of the sciences, arts, inventions, works, and their portions, according to the use and tribute which they yield and render to the conditions of man's life, and under those several uses, being as several offices of provisions, to charge and tax what may be reasonably exacted or demanded; not guiding ourselves neither by the poverty of experiences and probations, nor according to the vanity of credulous imaginations; and then upon those charges and taxations to distinguish and present, as it were in several columns, what is extant and already found, and what is defective and further to be provided. (iii.234)

We have here one of the most explicit connections between Bacon's proposals for the reform of law and his proposals for the reform of natural philosophy, for there are clear parallels between the organisation of the search for the fundamental principles of natural philosophy and of that for the fundamental principles of law. Both involve centrally guided, large-scale programmes, in which the right kinds of institutions are going to be crucial, but both also involve the particular kind of practitioner to carry out the tasks; and, at least in the case of natural philosophy, this particular kind of practitioner must go through what is in effect a purging process to remove or mitigate the effects of the internal impediments to knowledge.

'Purging the floor of the mind'

The internal impediments go to the core of the question of the natural philosopher, because the persona of the natural philosopher, and the very possibility of pursuing natural philosophy, are intimately tied up with mastery of the passions, and such mastery is largely possible because the 'Idols of the mind' have been identified and (where possible) remedied.

His first mention of internal impediments comes in *Valerius Terminus* in dealing with what he calls 'Anticipations', which he tells us are the 'voluntary collections that the mind maketh of knowledge; which is every man's reason.'³⁸ The term 'Anticipation' is capitalised by Bacon throughout, indicating a technical term, and the obvious contender is an English translation of the Greek term *prolepsis*, a crucial ingredient in Epicurean philosophy. Thomas Stanley, discussing the Epicureans in his *History of Philosophy*, translates *prolepsis* as 'Prænotion or Anticipation',³⁹ and this, taken with Bacon's concern with ancient atomism, make it sufficiently clear that Bacon is consciously employing an Epicurean term. The Epicurean view was that these 'Anticipations' were conceptions which, in the normal case, had been synthesised out of repeated sensory experiences, which were then applied to subsequent experiences. With sensations and feelings, they formed one of the three criteria of truth.⁴⁰ The thrust of Bacon's argument is that they are not reliable criteria, whereas sensations are. The contrast he draws is between 'Anticipations' and 'the information of the senses.' His point is that various forms of Pyrrhonism rightly demolished 'Anticipations' in antiquity, but that

³⁸ *Val. Term.: Works* iii.244.

³⁹ Stanley, *History of Philosophy*, iii.851.

⁴⁰ Epicurus, *Ratæ Sententiæ* (Key Doctrines), 24; *Letter to Herodotus*, 37–8, 82. Texts and translations in A. A. Long and D. N. Sedley, *The Hellenistic Philosophers*, 2 vols. (Cambridge, 1987), ii.91–2 (text), i.87 (trans.).

the Pyrrhonists and Academics who pursued these sceptical arguments made two errors. First, 'they ought when they had overthrown and purged the floor of the ruins to have sought to build better in place'. Second, 'they did unjustly and prejudicially to charge the deceit upon the report of the senses.' Bacon believes the senses should be immune from this criticism, 'not because they err not', but because it is not they that do the real work in the cognitive operations to which the sceptical arguments are directed; as he puts it, 'the use of the sense in discovering of knowledge is for the most part not immediate.'

Continuing the theme of 'Anticipations', he refers to those who 'have not had the resolution and strength of mind to free themselves wholly from Anticipations, but have made a confusion and intermixture of Anticipations and observations.'⁴¹ The idea is not that the mind remain without any conceptions whatsoever, but that these 'Anticipations' be replaced. Yet their replacement is not a straightforward matter, and

if any have had the strength of mind generally to purge away and discharge all Anticipations, they have not had that greater and double strength and patience of mind, as well to repel new Anticipations after the view and search of particulars, as to reject old which were in their mind before; but have from particulars and history flown up to the principles without the mean degrees, and so framed all the middle generalities or axioms, not by way of scale or ascension from particulars, but by way of derivation from principles; when hath issued the infinite chaos of shadows and notions, wherewith both books and minds have been hitherto, and may be yet hereafter much more pestered. (*Val. Term.: Works* iii.245–6)

The failure of attempts to provide something more worthwhile than 'Anticipations' is ultimately a failure in method: Investigators have not dealt properly with counterexamples, they have focused too narrowly on particular effects, they have ignored many common observations and restricted their attention to ones they deem particularly important, and so on. The upshot is that their efforts have been wasted.⁴² That this is not as evident as it should be is because they have devised techniques by which inadequacies in learning are covered up. Shortage of observations is covered up by making the subject into 'a solemn and formal art, by filling it up with discourse, accommodating it with some circumstances and directions to practice, and digesting it into method, whereby men grow satisfied and secure, as if no more inquiry were to be made of that matter.' Alternatively, gaps can be ignored by 'defining those effects which they cannot attain unto to be out of the compass of art and human endeavour.'

⁴¹ *Val. Term.: Works* iii.240.

⁴² *Ibid.: Works* iii.247.

There is a gap of about twenty years between Bacon's first account of 'Anticipations' and his full exposition of the 'Idols of the mind.' The second part of the 'Great Instauration', which is devoted to the 'invention of knowledge', rather than its 'cultivation',⁴³ has two components: One aims to rid the mind of preconceptions, the other to guide the mind in a productive direction. These components are interconnected, as Bacon makes clear in the Preface to *Novum Organum*:

I propose to establish progressive stages of certainty. I retain the evidence of the senses, helped and guarded by a certain process of correction [*reductio*], but I shall reject, for the most part, the mental operation which follows the act of sense; instead of it I open up and set out a new and certain path for the mind to proceed along, starting directly from simple sense perception. Those who attributed so much importance to Logic no doubt felt the need for this; for they showed thereby that they were in search of aids for the understanding, and had no confidence in the native and spontaneous process of the mind. But this remedy comes too late to do any good, when the mind is already, through the daily intercourse and conversation of life, occupied with unsound doctrines and beset on all sides by vain *idols*. And therefore that art of Logic, coming (as I said) too late to the rescue, and no way able to set matters right again, has had the effect of fixing errors rather than disclosing truth. There remains but one course for the recovery of a sound and healthy condition, namely, that the entire work of the understanding be commenced afresh, and the mind itself, right from the very beginning, should not be left to take its own course, but should be guided at every step; and the matter must be carried out as if by machinery. (*Works* i.151–2/iv.40)

In other words, various natural inclinations of the mind must be purged before the new procedure can be set in place. Bacon's approach here is genuinely different from that of his predecessors, as he realises. Logic or method in themselves cannot simply be introduced to replace bad habits of thought, which Bacon identifies as 'Idols', because it is not simply a question of replacement. The simple application of logic to one's mental processes is insufficient. Bacon's target here is a real one, for late Scholastic textbooks on logic do treat it very much as a corrective. Two such logic textbooks published three years after the appearance of *Novum Organum* bring this out clearly: In his *Brevis Summularum Recapitulatio* (1623), Chrysostomus Cabero deals with the question of whether logic offers a natural constraint on the mind or a morally binding norm on thought, and Raphael Aversa, in his *Logica* (1623), uses what is in effect a medical model, arguing that logic remedies the natural weaknesses of the mind. Late Scholastic textbooks generally took logic not as a theory designed to explain how to preserve truth between premises and conclusions, for example, but primarily as a normative theory of thought,

43 *Nov. Org.*: *Works* i.153/iv.42.

a theory of the regulation of the functions of cognition,⁴⁴ and works like Robert Sanderson's *Logicæ Artis Compendium* (1615), which describes the aim of logic as forming human reason and human speech, follow in this tradition. Logic textbooks as often as not took logic as a practical manifestation of Aristotelian–Thomistic psychology. Bacon's attempt to pursue epistemology by means of a psychology of knowledge was not novel; but the way in which he pursues it is. His psychology is derived more from the Roman rhetorical tradition than from Aquinas (a very significant difference in spite of the fact that in some respects both take their points of departure from Aristotle). Moreover, on Bacon's view the Idols are firmly entrenched and cannot be displaced simply by introducing something else. They must be purged before anything remotely resembling logical processes can even begin.

In his doctrine of Idols, Bacon provides an account of the systematic forms of error to which the mind is subject, and this is a crucial part of his epistemology. It is drawn, not from classical Greek philosophical sources such as Plato and Aristotle, but from a different kind of approach to the study of the mind, which depends upon the rhetorical tradition as much as anything else. The point has general significance, and it is evident in Bacon's move away from criticising the past in terms of particular theories advocated in antiquity and more in terms of what might be called mentalities. He contextualises the past, rejecting a particular way of dealing with problems in terms of the mentality that gives rise to that form of treatment. This move to mentalities is encouraged, if not initiated, by his psychological account of the sources of error.

It is in Bacon's treatment of internal impediments, the 'Idols of the mind', that the question is raised of what psychological or cognitive state we must be in to be able to pursue natural philosophy in the first place, and the purging of the passions – and by this means the 'Idols of the mind' – is part of the project of fitting us out to be natural philosophers. In other words, it is here that the question of the possibility of a viable natural philosophy and the question of the persona of the natural philosopher meet. Bacon believes an understanding of nature of a kind that had never been achieved since the Fall is possible in his own time because the distinctive obstacles that have held up all previous attempts have been identified, in what is in many respects a novel theory of what might traditionally have been treated under a theory of the passions, one directed specifically at natural-philosophical practice. Bacon's physico-theology provides his account of the legitimacy of pursuing natural philosophy in the first place, and it depends crucially on theory of the 'Idols of the mind'.

44 See my *Cartesian Logic* (Oxford, 1989), 38–47

The account of Idols is set out fully in the first two parts of the 'Great Instauration': in Chapter 4 of Book 5 of *De Augmentis*, and, more extensively, in Book 1 of *Novum Organum*. It is presented in a general way in *De Augmentis* in the following terms:

As for the detection of false Appearances or Idols, Idols are the deepest fallacies of the human mind. For they do not deceive in particulars, as the others do, by clouding and snaring the judgement; but by a corrupt and ill-ordered predisposition of the mind, which as it were perverts and infects all the anticipations of the intellect. For the mind of man (dimmed and clouded as it is by the covering of the body), far from being a smooth, clear, and equal mirror (wherein the beams of things reflect according to their true incidence), is rather like an enchanted mirror, full of superstition and imposture. Now Idols are imposed on the mind, either by the nature of man in general, or by the individual nature of each man, or by words, or nature communicative. The first of these I call Idols of the *Tribe*, the second the Idols of the *Cave*, the third the Idols of the *Market-place*. There is also a fourth kind which I call Idols of the Theatre, superinduced by corrupt theories or systems of philosophy, and false laws of demonstration. But this kind may be rejected and got rid of. . . . The others absolutely take possession of the mind, and cannot be wholly removed. (*Works* i.643/iv.431)

Bacon goes on to warn the reader that 'the doctrine regarding Idols cannot be reduced to an art; all that can be done is to use a kind of thoughtful prudence against them.'⁴⁵ This marks it out from the approach of late Scholastic logic textbooks, where 'the art of arts', logic, is deployed against bad habits of thought; but Bacon's approach also requires him to identify the specific sources of systematic error, and this is an even more significant difference. It is not just the authors of Scholastic textbooks who think there is a general solution to the problem of error but Descartes too: In the *Meditationes*, Descartes famously argues that we can treat those things of which we are uncertain as if they were false, in order that we might identify something indubitable. All sources of error are homogenised in Descartes, and there is no need to distinguish different sources of error any more than there is for the textbook authors. Bacon's strategy, however, requires that he identify the different sources of error, for this is a precondition of dealing with them, and until they can be dealt with, the application of procedures for discovery and the building up of knowledge, far from being able in themselves to root out basic systematic forms of error, cannot even begin.

The Idols of the Tribe derive from human nature itself, and affect everyone equally.⁴⁶ One particularly important manifestation of them is the eagerness to suppose that there is more order and regularity in na-

⁴⁵ *De Aug.*: *Works* i.643/iv.432.

⁴⁶ *Nov. Org.* I xli: *Works* i.163–9/iv.54–9.

ture than there actually is. Bacon's examples are the assumption of circular orbits for planets, the introduction of fire as an element to make up a perfect square of four elements, and the arbitrary assumption that the densities of the elements stand in ratios of ten to one. A second manifestation of this deficiency in the human mind is the tendency to neglect or ignore counterexamples to one's theories: The mind is more attentive to confirming instances than ones which go against one's theory. A third manifestation is the tendency to extrapolate from striking cases with which one is familiar to all other cases. A fourth is the restlessness of the human mind, which means it is not satisfied with perfectly good fundamental explanations, mistakenly and constantly seeking some more fundamental cause ad infinitum. A fifth is the tendency to believe true what one would like to be true, with the consequence that one

rejects difficult things from impatience of research; sober things, because they narrow hope; the deeper things of nature, from superstition; the light of experience, from arrogance and pride, lest his mind should seem to be occupied with things mean and transitory; things not commonly believed, out of deference to the opinion of the vulgar. (*Nov. Org.* I xlix: *Works* i.168/iv.57)

The 'greatest hindrance and aberration of the human understanding', however, derives from 'the deceptions of the senses.' We are told that 'speculation commonly ceases where sight ceases', with the result that insensible bodies, such as air, are 'almost unknown'. The unaided senses are unreliable, and it is only when bolstered by 'instances and experiments' that they gain a degree of reliability and usefulness. Finally, the sixth impediment lies in the fact that we are prone to resolve matters into abstractions, whereas what we should be doing is following Democritus and concentrating on matter rather than form.

What marks out the Idols of the Tribe is the fact that they are inherent in human nature, but beyond this their grouping looks somewhat forced. Bacon tells us that they derive from

the homogeneity of the substance of the human mind, or from its preoccupation, or from its narrowness, or from its restless motion, or from an infusion of the affections, or from the incompetence of the senses, or from the mode of impression. (*Nov. Org.* I lii: *Works* i.169/iv.58–9)

Although the idea that there may be inherent impediments to knowledge that are deeply entrenched and common to everyone does not seem particularly contentious, bringing together the six things that Bacon identifies as Idols of the Tribe masks deep differences. When we consider their targets, for example, it is apparent that some are very contentious, and it is far from clear that what is being criticised can simply be dismissed as an impediment of the mind. The first, for example – the unwarranted assumption of order and regularity in nature – is principally

directed against pursuing astronomy mathematically. The fourth – not being satisfied with perfectly good explanations – seeks to draw the line on the question of where explanations stop at the level of atomism/corpuscularianism without any defence of this. The sixth – the attempt to explain in terms of abstractions – is antirealist (in the sense of being nominalist) and advocates atomism/corpuscularianism without any argument. On the other hand, in the case of the second deficiency – the tendency to ignore contrary evidence – Bacon is on strong ground. He can fill out the criticism, and his account of eliminative induction gives us a good idea of just what we can do to correct for this deficiency. Similarly, the idea that there is a tendency to assume to be true what one would like to be true raises genuine criticisms of traditional ways of pursuing natural philosophy, and the criticism of the procedure of extrapolating from striking cases, while it clearly needs detailed spelling out, does genuinely identify a problem.⁴⁷

The Idols of the Cave, we are told, ‘take their rise in the peculiar constitution, mental or bodily, of each individual; and also in education, habit, and accident.’⁴⁸ But again, what we are offered is a somewhat heterogeneous listing. Setting out the sources of these Idols in a little more detail, Bacon lists a number of more specific causes. The first is fascination with a particular subject, which leads one to extrapolate to other areas – Aristotle extends logic to natural philosophy, alchemists move from a few experiments to the whole of the discipline, Gilbert from a detailed study of the lodestone to a cosmological system. There is perhaps something to be said for this criticism, and although it might be noted that Bacon’s own account of natural philosophy is not immune to it, one can see how his procedure of eliminative induction might guard against it. Indeed, it is here, on the question of hasty overgeneralisation, that the real strength of eliminative induction becomes evident. The second source is the readiness of some minds to focus on differences, and some to focus on similarities and resemblances, whereas a balance is difficult to attain naturally. Another kind of difference is that between minds which are overly attracted to antiquity and those that are overly attracted to novelty. Finally, there are those who are concerned wholly with material constitution at the expense of structure (the ancient atomists), and those who are concerned wholly with structure at the expense of material constitution.⁴⁹

47 See the discussion of ‘Deviating Instances’ at *Nov. Org.* II xxix: *Works* i.282–3/iv.168–9. Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150–1750* (New York, 1998), 221–2, point out that, whereas the traditional encyclopædists see the study of wonders as supplementing Aristotelian natural history, Bacon sees their study as undermining Aristotelian natural history.

48 *Nov. Org.* I liii: *Works* i.169/iv.59.

49 *Nov. Org.* I lvii: *Works* i.170/iv.60.

These examples bring to light what I believe is a very significant difference between the Idols of the Tribe and Idols of the Cave. There seems to be a set of routine procedures through which one can go to remedy the situation in the latter case, procedures which are provided by the positive part of Bacon's doctrine – eliminative induction – whereas the Idols of the Tribe are, in most cases, much more difficult to remedy. In his discussion of rhetoric in *De Augmentis*, Bacon tells us that there are three sources of the disturbance of reason, and three corresponding remedies. If the reason is misled by sophisms, the solution lies in logic; if it is misled by wordplay, the remedy lies in rhetoric; and if it is misled by passions, the remedy lies in moral philosophy.⁵⁰ At the most general level, it seems we have little more to go on than this tripartite division of responsibilities.

The Idols of the Market-place derive, in essence, from the fact that we have to express and communicate our thoughts by means of language, which contains systematic deficiencies. One kind of problem with language lies in the fact that words

are commonly framed and applied according to the capacity of the vulgar, and follow those lines of division which are most obvious to the vulgar understanding. And whenever an understanding of greater acuteness or a more diligent observation would alter those lines to suit the true divisions of nature, words stand in the way and resist the change. (*Nov. Org.* I lix: *Works* i.171/iv.61)

This leads to two kinds of linguistically induced deficiencies. First, language provides names which refer to things that do not exist, such as 'Fortune, Prime Mover, Planetary Orbits, Element of Fire, and like fictions which owe their origin to false and idle theories.'⁵¹ The solution here is simply to get rid of the theories that give rise to these fictitious entities. The second kind of case is not so straightforward. It arises because words have multiple and/or ill-defined meanings, and this is especially so in the case of terms – such as 'humid' – which have been abstracted from observation. Bacon discerns a gradation in the 'degrees of distortion and error' of terms,⁵² beginning with names of substances, where the degree of distortion is low, proceeding through the names of actions, and finally reaching the names of qualities – he gives the examples of 'heavy, light, rare, dense' – where the degree of distortion is high.

The cause of this parlous state of language seems clearly to lie in the Fall, since the discussion of Adam's knowledge of the 'true names' of

50 *De Aug.* VI: *Works* iv.455. Cf. *Adv. Learn.* II: *Works* iii.409, where rhetoric is described as a remedy for the reason being misled by the imagination.

51 *Nov. Org.* I lx: *Works* i.171/iv.61.

52 *Ibid.*, lx: *Works* i.172/iv.62.

things in *Valerius Terminus*, at which we looked earlier, indicates that there was originally an exact correspondence between words and things: It was in fact a standard assumption of the time that Adam was able to decode the nature of every creature from its name. The Proemium to *De Augmentis* explicitly demands a restoration of this state, asking 'whether that commerce between the mind of man and the nature of things, which is more precious than anything on earth . . . might by any means be restored to its perfect and original condition, or if that may not be, yet reduced to a better condition than that in which it is in now.'⁵³ This aim applies equally to all the Idols, but it does have a special bearing on the Idols of the Market-place. Somewhat surprisingly, Bacon does not suggest a general remedy here; but since a reform of natural philosophy, though it would certainly clear language of nonreferring terms, would not wholly remove the problem, it would seem that a wholesale reform of language was ultimately the only avenue, and such reform was indeed pursued vigorously by many writers in the seventeenth century, with Bacon's influence evident in many of the English cases.⁵⁴ Failing wholesale reform, a conscious choice of plain, concise language was made; but whereas in sixteenth- and early-seventeenth-century writers such as Lipsius this might have been defended along classical lines, as employing the Attic model of Seneca and Tacitus, things have now changed radically. Thomas Sprat, the first historian of the Royal Society, writing in 1667, tells us that the ideal of the early members was 'a close, naked, natural way of speaking; positive expressions, clear senses; a native easiness: bringing all things as near a mathematical plainness, as they can', but he characterises this as a preference for 'the language of Artizans, Countrymen, and Merchants, before that, of Wits, or Scholars'.⁵⁵

The fourth kinds of impediment, the 'Idols of the Theatre', are neither innate in the mind nor in language but are acquired from a corrupt philosophical culture and its perverse rules of demonstration. Here a general remedy is available, namely following Bacon's positive methodological prescriptions:

53 Works iv.7.

54 See James Knowlson, *Universal Language Schemes in England and France, 1600–1800* (Toronto, 1975), and M. M. Slaughter, *Universal Language and Scientific Taxonomy in the Seventeenth Century* (Cambridge, 1982). The most famous proposed reform of language was that set out by John Wilkins in *An Essay towards a Real Character, and a Philosophical Language* (London, 1668), where he tries to connect 'real characters' with 'natural species'. In England and France (Germany was an exception), this approach did not really survive Locke, who argued that 'Boundaries of *Species*, are as Men, not as Nature makes them' (*Essay*, Book 3, chap. 6, in *The Works of John Locke Esq.*, 2d ed., 3 vols. [London, 1722], i.209).

55 Thomas Sprat, *The History of the Royal-Society of London for the Improving of Natural Knowledge* (London, 1667), 113

The course I propose for the discovery of sciences is such as leaves but little to the acuteness and strength of wits, but places all wits and understandings nearly on a level. For as in the drawing of a straight lines or a perfect circle, much depends on the steadiness and practice of the hand, but if with the aid of a rule or compass, little or nothing; so is it exactly with my plan. (*Nov. Org.* I lxi: *Works* i.172/iv.62–3)

In following Bacon's methodological prescriptions, we are able to return to something approximating a prelapsarian state. Adam's knowledge was direct and intuitive, ours is not. To achieve something that approximates to this original state we must give up any hope of relying on our wits and must accept the rigour of a mechanical rule, which bypasses not only the weaknesses of the mind but to some extent its strengths as well. This is a high price by any standards, particularly by those of the humanist culture from which Bacon took his original bearings, a culture in which a high value is placed on individuality; but Bacon clearly believes that consideration of his mechanical rule and its benefits will show it outweighs such considerations.

One of the great values of Bacon's account of the Idols is that it allows him to make the case for method in a particularly compelling way. Indeed, never has the need for method been set out more forcefully, for Bacon's advocacy of method is not simply as an aid to discovery. We pursue natural philosophy with seriously deficient natural faculties, we operate with a severely inadequate means of communication, and we rely on a hopelessly corrupt philosophical culture.⁵⁶ In many respects, these are beyond remedy. The practitioners of natural philosophy certainly need to reform their behaviour, overcome their natural inclinations and passions, and so on, but not so that, in so doing, they might aspire to a natural, prelapsarian state in which they might know things as they are with an unmediated knowledge. This they will never achieve. Rather, the reform of behaviour is a discipline to which they must subject themselves if they are to be able to follow a procedure which is, in many respects, quite contrary to their natural inclinations, at odds with traditional conceptions of the natural philosopher, and which is indeed subversive of their individuality.

⁵⁶ This message was not lost on Bacon's successors. Hooke, for example, in the Preface to his *Micrographia; or, Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses with Observations and Inquiries thereupon* (London, 1665), points to 'the mischiefs, and imperfections, mankind has drawn upon it self, by negligence, and intemperance, and a wilful and superstitious deserting of the Prescripts and Rules of Nature, whereby every man, both from a deriv'd corruption, innate and born within him, and from his breeding and converse with men, is very subject to slip into all sorts of errors.'

It seems to me that a parallel with the Jesuits is worth drawing here. Ignatius Loyola had formed a 'society' consisting of a highly educated and highly motivated élite who would carry out the demands of the pope and the church *perinde ac cadaver*: 'as if they were but corpses'. Bacon might well wish of the Jesuits, in the *Advancement of Learning*, that 'they were on our side',⁵⁷ for in many respects they are exactly the kind of people he needs. Indeed, his *New Atlantis* is suggestive in this respect. The mythical Pacific island described there, which Rawley – his chaplain and amanuensis, and the work's editor (it was published posthumously in 1627) – points out was intended to provide a model 'of a college instituted for the interpreting of nature and the producing of great and marvellous works for the benefit of man',⁵⁸ is a monarchy, but the organ of government we are introduced to are the 'Fathers', a select group of natural philosophers who supervise a huge state-regulated scientific programme. It is worth noting that Spanish is the language spoken, and the degree of centralised organisation suggests that it is Spain, or perhaps even the Jesuits (we are not told whether the 'Fathers' of Solomon's House have been ordained priests, but they are priestlike in their behaviour and demeanour) rather than James's England that is being envisaged.

I am not suggesting that Bacon used the Society of Jesus as a model. The point is rather that he did not need to: The idea of a highly educated élite whose members lead a relatively ascetic life and subject themselves to a rigorous intellectual discipline – and to a single sovereign – is perhaps not so alien to Reformation/Counter-Reformation culture as to preclude a number of manifestations. What we have in the extensive purging and subjection to a method that constitute Bacon's approach – 'I do not slight the understanding, but govern it'⁵⁹ – is a version of the spiritual exercises which had been part of philosophy in antiquity,⁶⁰ which Ignatius and Bacon, each in their different ways, fostered in a

57 *Adv. Learn.* I: *Works* iii.277.

58 *New Atl.*: *Works* iii.127. Bacon was not the first to give a significant degree of precedence to natural philosophy in a utopian vision. Tommaso Campanella had done so in his *Città del sole*, written in 1602 (Frankfurt, 1623), and he had suggested the wider dissemination of scientific knowledge by having pictures of scientific activity painted on both sides of the seven concentric walls of the circular city and on a globe beneath the cupola of the central temple. Also, Johann Valentin Andreae, in his *Reipublicæ Christianopolitanæ Descriptio* (Strasbourg, 1619), treats the pursuit of natural philosophy as a sacred occupation. See the account in Frank E. Manuel and Fritzie P. Manuel, *Utopian Thought in the Western World* (Cambridge, Mass., 1970), chaps. 10 and 11.

59 *Nov. Org.* I cxxvi: *Works* i.219/iv.112.

60 See Hadot, *Philosophy as a Way of Life*, and his *Plotinus; or, The Simplicity of Vision* (Chicago, 1993); Paul Rabbow, *Seelenführung: Methodik der Exerzitien in der Antike* (Munich, 1954).

fashion which met what they saw as the demands of the age. It might appear that submission to such a procedure is in direct conflict with traditional conceptions of the philosopher, which were modelled around the moral philosopher, who is a paradigmatically free agent and precisely the kind of person who never has to follow a rigid procedure, for that would be anathema to the contemplative life. There is something right about this view of traditional philosophy, although the contrast is overdrawn in some important respects, for when we look at the philosophical schools that flourished in antiquity (particularly late antiquity), where questions of the training of philosophers are concerned, we do in fact find that the procedures which are recommended if someone is to train to think and behave philosophically are often quite constrictive and demanding. Even this, however, is not enough for Bacon's needs. The discipline to which natural philosophers must subject themselves, if they are to be able to follow a procedure which is in many respects quite contrary to their natural inclinations, is something which, if not wholly at odds with them, certainly strains traditional conceptions of the philosopher. What Bacon is recommending is subversive of the individuality of philosophers, and is more than might have been expected out of the members of the Hellenistic schools of philosophy: It is more along the lines of what might be expected of a person taking up the religious life.

In this respect, the quasi-religious standing of the 'Fathers' who oversee Solomon's House in the *New Atlantis* is instructive, and the Jesuits might help us understand the kind of thing at issue here. The problem is to conceive of how the new practitioners of natural philosophy might on the one hand be subservient to a rigid methodology in their natural-philosophical work, and to a single sovereign in the guidance of their programme, while at the same time being at the vanguard of the comprehension of the natural world, and being the paradigm of wisdom and understanding. The task Loyola set his Society of Jesus was not that different, and I suspect that many courtier cultures worked along similar lines. If we see matters in this light, we might perhaps see what Bacon is offering as an alternative to Jesuit natural philosophers like Clavius, and courtier natural philosophers like Galileo.⁶¹

It is, nevertheless, the Jesuits who give us the best idea of the kind of thing that Bacon envisaged. They were in the vanguard of the Counter-Reformation's philosophical and theological reform, having been found-

61 On Galileo, see Mario Biagioli, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism* (Chicago, 1993). There is nothing comparable on Clavius, but there are two good accounts of his work in James M. Lattis, *Between Copernicus and Galileo: Christoph Clavius and the Collapse of Ptolemaic Cosmology* (Chicago, 1994), and in chap. 2 of Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago, 1995).

ed to carry out the demands of the pope and the church without question. They subjected themselves both to a rigorous intellectual discipline and to the complete direction of a single sovereign, the pope; yet far from being automata, they were among the leading thinkers of the day. There was no incompatibility here. The case of the Jesuits helps us understand how, on the one hand, we can have an élite group of philosophers/natural philosophers at the forefront of their area,⁶² and on the other, how they can be completely subject to a higher authority, a sovereign. However, it also brings to our attention the other side of the coin, for it additionally reveals a deep ambiguity in this élite, brought out in a striking way by the comment of the Jesuit general Pedro Arrupe in 1981: 'Perhaps we have geniuses in our company, but precious few! A long time ago it was said that the Company's strength lay in its well-trained mediocrity. . . . In Saint Ignatius' thinking, excellence is not of an intellectual order.'⁶³ When we recall Bacon's claim in *Novum Organum* –

my way of discovering sciences goes far to level men's wits, and leaves but little to individual excellence; because it performs everything by the surest rules and demonstrations (*Nov. Org.* I cxxii: *Works* i.217/iii.109)⁶⁴

– we are perhaps prompted to consider yet another, deeper problem: the identity of the natural philosopher. In his Preface to *New Atlantis*, Rawley points out that Bacon had originally intended to include 'a frame of Laws, or of the best state or mould of a commonwealth.'⁶⁵ Such questions, as well as morality, civil philosophy, and the control of the passions – as the *Advancement of Learning* and *De Augmentis* make clear – come to bear upon the discipline of natural philosophy because the natural philosopher is not simply someone with a particular expertise, or even someone who has a range of expertises, but someone who is to play a role as the standard bearer of a new kind of learning, both theoretical and practical. This is a role which, as I mentioned earlier, brings with it a quasi-moral authority, replacing the image of sage as moral phi-

62 On Jesuit contributions to cosmology in the last decades of the sixteenth and the early decades of the seventeenth century, see, e.g., Lattis, *Between Copernicus and Galileo*, and Dear, *Discipline and Experience*, chap. 2. The case to be made for natural history generally – e.g., in the *The Natural and Moral History of the Indies* of José de Acosta, which appeared in English in 1604 (trans. Edward Grimston [London]) and from which Bacon borrowed extensively for his 'Great Instauration', above all in the material on winds – and in particular areas, such as pharmaceutical botany, is even greater.

63 Quoted in Jean Lacouture, *Jesuits, a Multibiography* (London, 1996), 476.

64 Cf. *Val. Term.*: *Works* iii.250, and *Nov. Org.* I lxi: *Works* i.172/iv.62–3, cited earlier in this section.

65 *New Atl.*: *Works* iii.127.

philosopher with that of the sage as natural philosopher. But who is the natural philosopher in Bacon's account? The person who carries out the directed work that Bacon envisages certainly needs certain qualities of mind, a certain mentality, as well as particular skills and understanding, but the whole point of Bacon's account of method is that this work can be largely routinised. Bacon certainly did not see himself following his routinised method: As he remarks in connection with experiment and observation in the *Parasceve*, 'I hold it to be somewhat beneath the dignity of an undertaking like mine that I should spend my own time in a matter which is open to almost every man's industry.'⁶⁶ Those radical Puritans who, in the decades after Bacon's death, took him as their model for a democratised science, who wanted to close down the universities and replace their teachers with 'Weavers, (or Combers of Wool) Cobblers, Fullers, and Illiterate and Exceeding Rusticke'⁶⁷ were probably wide of the mark, as were those late-eighteenth-century French advocates of Baconianism in the debate over 'republican' versus 'monarchical' science, who employed Bacon in the advocacy of natural history as a nonélitist form of science.⁶⁸ It would seem that, for Bacon, it is the sovereign who, in the image of Solomon, the philosopher-king, directs the work – and that it is the sovereign, rather than those who perform this directed work, who is the natural philosopher par excellence.

⁶⁶ *Parasceve: Works* i.393–4/iv.251–2.

⁶⁷ Henry Stubbe, *A Light Shining out of Darkness* (London, 1659), 18. Quoted in Charles Webster, *The Great Instauration: Science, Medicine and Reform (1626–1660)* (London, 1975), 174.

⁶⁸ See William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, 1994), 349

Method as a way of pursuing natural philosophy

The 'Great Instauration'

When *Novum Organum* was first published in 1620, among the various short pieces with which it was prefaced was a general plan of the parts of the projected 'Great Instauration'. This *Distributio Operis* divides the project into six parts.¹ The first, which Bacon describes as 'a summary or general description of the knowledge which the human race at present possesses', was entitled 'division of the sciences', which had been the theme of the *Advancement of Learning*, and would be covered in a comprehensive way in the revised Latin version, *De Dignitate & Augmentis Scientiarum*. The latter was written for a continental audience and revised accordingly, and it was indicative of Bacon's realisation that little was likely to be done to implement his scheme in England, and of his desire to reach a wider audience.²

The second part is 'the New Organon, or Directions concerning the Interpretation of Nature'. The aim here is to equip the intellect to pass beyond what is already known. It is covered in *Novum Organum*, and although much earlier work on method is incorporated into *Novum Organum*, its detailed and comprehensive treatment makes it invaluable, and it has been widely regarded as Bacon's principal lasting contribution to natural philosophy – an assessment which I believe is entirely correct. Nevertheless, it is incomplete and was clearly intended to comprise

¹ *Distrib. Op.*: Works i.134/iv.22.

² Indeed, it did prove popular, both on the Continent and in England. Latin editions appeared in France (1624), Germany (1635), and the Netherlands (1645), and continued to be reprinted throughout the seventeenth century, with a French translation appearing in 1632 and an English one in 1640. The English translation, which was printed twice in 1640 and saw a new edition in 1674, completely superseded *The Advancement of Learning*, the last seventeenth-century edition of which was published in 1633. See R. W. Gibson, *Francis Bacon: A Bibliography of His Works and of Baconiana, to the Year 1750* (Oxford, 1950) for details.

more than the two books which Bacon managed to complete: In Book 2, he sets out nine major topics he will take up, the first seven of which seem relevant to the second part of the project, but he deals only with the first of these.³ This second part of the 'Great Instauration' is our concern in this chapter.

The third part is designed to comprise 'a natural and experimental history for the foundation of philosophy'. A large number of works, both fragmentary and substantial, had been devoted to this question before 1620, and in the 1620s Bacon makes a concerted effort to build up this part of the programme, in 1622 devising a plan to publish instalments on a monthly basis. These works are the subject of Chapter 6, which is devoted to his substantive achievements in natural philosophy.

The first three parts of the 'Great Instauration' Bacon describes as being designed to surround 'the intellect with faithful helps and guards'.⁴ Once this has been achieved, the next stages can be begun, namely, supplying various examples for guidance; building up a provisional body of theory which has not been arrived at according to his rules of method and so is not guaranteed to be reliable; and, finally, 'the sixth part of my work (to which the rest is subservient and ministrant) discloses and sets forth that philosophy which by the legitimate, chaste, and severe course of inquiry which I have explained and provided is at length developed and established.'⁵ Material for the last three parts is absent from the writings of the 1620s.

Atomism: method and natural philosophy

The second and third parts of Bacon's 'Great Instauration' are not so easy to separate as they might seem, and this is because the relation between 'method' and Bacon's substantive natural philosophy is not straightforward. Although it might look at times as if he is applying some epistemologically *sui generis* method, at other times his method seems to be guided by a particular conception of just what natural philosophy is at the most fundamental level, namely a theory of matter, something which is not only at odds with other ways of pursuing natural philosophy in the seventeenth century, most notably via mechanics, but which also brings with it quite specific constraints on method which are different from those operative if one were, for example, to pursue natural philosophy via mechanics. Moreover, the theory of matter is em-

3 *Nov. Org.* II xxi: *Works* i.268/iv.155. In Aphorisms xlix and l (*Works* i.349/iv.233) he tells us that he will discuss certain questions later, under the head of two of these topics: 'Applications to Practice' and 'Modes of Experiment'.

4 *Distrib. Op.*: *Works* i.143/iv.31.

5 *Ibid.*: *Works* i.144/iv.32.

bedded in a metaphysics of reality versus appearances in a way that mechanics is not; for although this question does occasionally intrude into the latter, most famously in the case of the physical interpretation of the heliocentric theory, it is in no sense constitutive of the enterprise, and has little meaning as a way of describing most forms of inquiry in mechanics. His method revolves around the notion of going beyond merely surface appearances to get to the underlying reality. This it shares with Aristotle's natural philosophy, but not, say, with Galilean kinematics. When Galileo shows that, whatever their resultant motion in a resisting medium, all bodies have a component of uniformly accelerated motion downwards, and that this is the only universal component in terrestrial motion, he is not in any sense showing that uniformly accelerated motion is the reality underlying the appearances: That would be a completely inappropriate way of trying to capture wherein the significance of the result lies. In this respect, there is a gulf separating matter theory and mechanics as the fundamental natural-philosophical disciplines. To the extent to which method is 'natural-philosophy specific' in Bacon, we can only think of Baconian method as a candidate for a general theory about scientific investigation if we share his conception of the role of the theory of matter as the fundamental natural-philosophical discipline.⁶

Bacon believes his account of method holds the key to the renovation of natural philosophy, which has come to be seen by many as a hopeless task. 'Of the impediments which have been in the affections', Bacon tells us in *Valerius Terminus*,

the principle whereof hath been despair of diffidence, and the strong apprehension of the difficulty, obscurity, and infiniteness which belongeth to the invention of knowledge, and that men have not known their strength, and that the supposed difficulties and vastness of the work is rather in shew and muster than in state or substance where the true way is taken. That this diffidence hath moved and caused some never to enter the search, and others when they have been entered either to give over or to seek a more compendious course than can stand with the nature of true search. (*Works* iii.249)

Those who have been driven by the apparent hopelessness of the task to give up any 'invention of knowledge' on their own part have either resorted to ancient authorities, or 'to revelation and intelligence with spirits and higher natures.' Others, after much labour, have hit upon

6 Gassendi may have shared this conception, but Descartes and Galileo did not, although the role of matter theory is never straightforward in seventeenth-century natural philosophy. On Descartes and Galileo, see my 'The Foundational Role of Hydrostatics and Statics in Descartes' Natural Philosophy', in Stephen Gaukroger, John Schuster, and John Sutton, eds., *Descartes' Natural Philosophy* (London, 2000), 60–80.

something only to find the same discovery in some ancient authority, and conclude that they could have learned things much more easily in the first place by relying on ancient authorities. Bacon sees his method as being crucial here, for this method, in contrast to the practices of antiquity, 'doth in sort equal man's wits, and leaveth no advantage or pre-eminence to the perfect and excellent motions of the spirit.'⁷

The general question of just what comprises true rules of demonstration was something that had particularly preoccupied Renaissance readers of Plato and Aristotle, and Ramus's criticisms of Aristotle had fuelled the debates. There can be little doubt that this is the context in which Bacon's concern with demonstration must be placed, and some specific connections, with Ramus's account, for example, can be established.⁸ But Bacon's account of method is not an abstract exercise in epistemology, and his atomist natural philosophy forms part of the same project, not by fleshing out a preconceived method but by showing what is needed of a method: what it is that a method must enable one to do.

The point can be brought out by comparing Bacon's approach with that which it is designed to replace. The requirements on Bacon's theory of method are very different from those on an Aristotelian account. Like Aristotle, Bacon thinks that natural philosophy relies at the most fundamental level on a theory of matter, but whereas the potentialities and tendencies of Aristotle's physical theory seem to inhere in matter without being physically identifiable in their own right, in Bacon's account they are present at the microscopic level in a physical way,⁹ and they are occasionally manifest at the macroscopic level in a physical way: squeezing, stretching, contraction, dilation, distension. For Bacon, but not for Aristotle, the causes of material processes are themselves material – they are no different in kind from their effects – and one thing a method should provide is a means of working back from manifest physical effects to their underlying physical causes. In other words, because Bacon construes the underlying causal processes that give rise to physi-

7 *Val. Term.: Works* iii.250.

8 See, for example, F. H. Anderson, *The Philosophy of Francis Bacon* (New York, 1971), chaps. 6 and 12.

9 It should be noted that Bacon never imagined that we would have direct access to this level of nature. In particular, there is no indication that he believed that magnification will take us down to the atomic structure of things, only make out detail at a few levels of magnitude greater than ordinary vision. See Catherine Wilson, *The Visible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton, 1995), chap. 2. The Oxford Baconians of the 1650s were to take a more optimistic view, and the microscope became a preoccupation with them, a preoccupation which finally flowered in Hooke's *Micrographia* (London, 1665): See Charles Webster, *The Great Instauration: Science, Medicine and Reform (1626–1660)* (London, 1975), 165–70.

cal effects in a very different way from Aristotle, we would naturally expect the procedures for the discovery of these processes to be very different from those recommended by Aristotle: and not just Aristotle, but critics of Aristotle such as Ramus. Unless we take into account the very different requirements on theories of method, any exploration of the resulting methodological differences can only be superficial, so it is important that we bring to light the extent to which his treatment of methodological questions reflects and meets these requirements. This difference is not just reflected at the methodological level, but to some extent actually drives differences at that level. It is such physically distinct states of matter that must be identified, for they are the causes of the processes we wish to explain, and method should ultimately guide us to such states. Of course, an Aristotelian would not think such states fundamental, so if that is where the method guided us, it would not have taken us anywhere near the principles underlying things that generated their essential properties. In this respect, Bacon's method would be completely beside the point to an Aristotelian.

Second, on Bacon's characterisation, what he is after is something practical, whereas Aristotle is aiming at something purely theoretical. This is brought out in an instructive way in *Cogitationes de Natura Rerum*, where he criticises Aristotle's account of the distinction between natural motions (rectilinear in the case of terrestrial bodies, circular in the case of celestial ones) and violent motions, not on the grounds that the distinction is mistaken, but on the grounds that Aristotle's concern is with the explanation of natural motions and states rather than violent ones.¹⁰

10 Aristotle had distinguished between natural objects and processes on the one hand, and artefacts and unnatural or constrained or violent processes on the other. Natural philosophy, for Aristotle, was concerned to explain the properties of things in terms of their essences. What lies at the basis of his schema is the distinction between those things that have an intrinsic principle of change, and those things that have an extrinsic principle of change. Acorns, and stones raised above the ground, both come in the first category; the former has within itself the power to change its state, into an oak tree, the latter has the power to change its position, to fall to the ground. In neither case is anything external required for the change/motion to occur. Aristotle thought that we explain and understand things by understanding their natures, where to give the nature of something is to give the ultimate characterisation of it. If we ask why a stone falls, the answer is that stones are heavy and heavy things fall: That is all there is to it. If we are asked why this tree puts out broad flat leaves in spring and keeps them through the summer, we may reply that it does this because it is a beech. In other words, we do not feel it is necessary to look outside the thing to account for its behaviour. And wherever we feel that we can explain a thing's behaviour, partly at least, without looking outside the thing, we think that its behaviour, and the feature that it acquires or retains, is nat-

Bacon's point is that it is 'violent', not natural, motions which are the ones of interest: They are 'the life and soul of artillery, engines, and the whole enterprise of mechanics.'¹¹ It is important to note at this point that the criticism is not that Aristotle's approach does not yield a true account of things. Use, not truth, is what is at issue. Aristotle's approach to natural philosophy is fine for someone seeking a contemplative understanding of natural phenomena, that is, for the philosopher who shapes his concerns around *otium*; but if one is guided by *negotium*, it will be wholly inadequate, because it will not deal, or will deal only peripherally, with those natural-philosophical questions than give natural philosophy its legitimacy as a worthwhile area of inquiry in the first place. Bacon distinguishes between understanding how things are made up and of what they consist, an exercise he associates with disputatious Scholastics, and by what force and in what manner they come together, and how they are transformed. It is the latter that we must seek to understand, for this is what leads to the augmentation and amplification of human powers. To restrict ourselves to the former is to approach nature as if we were examining the anatomy of a corpse. We must not concern ourselves with the classification of motions as being natural or violent, as Aristotle did, but investigate instead those 'appetites and inclinations and things by which all of the many effects and mutations that are evident in the works of nature and art are made up and brought about.'¹² We should tie nature down – *vincula injiciamus* – like Proteus, the sea-god who could take any shape, but if held until finally he was forced to take his true shape, would then answer any question. In this way, we will discover and distinguish the different kinds of motion, and then we will be able to hasten or arrest these, and by doing this change and transform matter.

ural. It is natural for stones to fall, it is the nature of beeches to have broad flat leaves. Such explanations are explanations of unconstrained, internally generated natural processes, and explanations of this kind lie at the core of Aristotle's natural philosophy. Unnatural or constrained or 'violent' states and processes might be caused by any number of extrinsic processes, and natural philosophy cannot be expected to account for these: A stone falling to the ground when released from constraints has a single explanation which refers us to an intrinsic cause, whereas a stone rising from the ground can have any number of causes, and natural philosophy cannot be expected to enumerate or account for these. This does not mean that Aristotle does not deal with violent motions at all, but they are not the central cases for his analysis and they cannot be dealt with in a systematic way. There is a good discussion of these issues in William Charlton, *Aristotle's Physics I, II* (Oxford, 1970).

11 *Cog. Nat. Rer.: Works* iii.29/v.433.

12 *Ibid.: Works* iii.20/v.425.

'A new and certain path'

Bacon's method – that is, his method of eliminative induction, which we shall explore in detail below – is set out in detail in *Novum Organum*, and it is in effect the showpiece of his programme. Important as the Idols are as an attempt to set out the kinds of error and misunderstanding to which we are subject when we pursue any cognitive endeavour, and important as they are, for him, as part of an understanding of our postlapsarian state, there can be little doubt that for Bacon they are above all a means of identifying just what must be remedied, and that supplying the remedies – to the greatest extent possible – is the ultimate aim of the project. The one systematic remedy – other than the reform of language, which Bacon does not pursue – is the provision of a method of inquiry which allows us to transcend our natural cognitive deficiencies. The second book of *Novum Organum* is devoted to this end.

Bacon begins with very characteristic definitions of the aims of human knowledge and human power, respectively, to discover what gives things their particular natures, 'to discover their Form, or true specific difference'; and 'to generate and superinduce a new nature or new natures in a body' (e.g., make silver a golden colour or make an opaque stone transparent) or to transform or transmute a body.¹³ A knowledge of efficient and material causes will lead to a very limited number of discoveries, for 'these are merely vehicles which convey the Form', whereas someone who knows the Forms of things

embraces the unity of nature in substances the most unlike; and is able therefore to detect and bring to light things never yet done, and such as neither the vicissitudes of nature, nor industry in experimenting, nor accident itself, would ever have brought into act, and which would never have occurred to the thought of man. From the discovery of Forms therefore results truth in speculation and freedom in operation. (iii: *Works* i.229/iv.120)

Moreover, Forms are both necessary and sufficient for any effect they have. As Bacon puts it,

the Form of a nature is such, that given the Form the nature infallibly follows. Therefore it is always present when the nature is present, and universally implies it, and is constantly inherent in it. Again the Form is such, that if it be taken away the nature infallibly vanishes. Therefore it is always absent when the nature is absent, and implies its absence, and inheres in nothing else. (iv: *Works* i.230/iv.121)¹⁴

13 *Nov. Org.* II i: *Works* i.227/iv.119. Subsequent citations in this section to Book 2 of *Novum Organum* will be given parenthetically in the text solely by section number and *Works* volume and page.

14 Cf. *Val. Term.*: *Works* iii.235–6.

Before we look at Forms, some discussion of how Bacon sees causation generally will be helpful. What Bacon is seeking is the discovery of causes which are both necessary and sufficient for their effects. He points out that Aristotle, in his doctrine of the convertibility of axioms, was in effect seeking the same thing, without being able to discover it.¹⁵ We need to ask, Why should Aristotle, and Bacon following him, place such strong constraints on causation, so that we only call something a cause when the effect always occurs in the presence of this thing and never in its absence? Bacon will make a similar point – and on the face of it, a similarly puzzling one – in relation to truth, putting an extremely strong condition on truth, namely, that something can only be a truth if, as well as meeting other criteria, it is useful. The problem is what these very restrictive criteria signify. I shall look at the case of truth in the penultimate section of this chapter. For the moment we need to ask whether there is an understanding of causation which makes sense of Aristotle's and Bacon's stipulations.

Remember that, in the final analysis, what Aristotle is after are the ultimate explanations of things, and it is natural to assume that ultimate explanations are unique. Natural processes, on Aristotle's construal of them, have single ultimate explanations: This marks them out from artificially induced processes, which may have any number of causes, which is why he considers the latter are not comprehensible in scientific terms. There is only one cause of the 'natural' motion of a body falling freely to the ground – its heaviness – whereas there are all kinds of purely contingent events that might result in a 'violent' or unnatural motion of the body: its being lifted upwards from its natural place, for example. Moreover, in the case of the natural motion of fall, in the absence of the cause, heaviness, bodies will not fall freely to the ground: Heaviness is both necessary and sufficient to explain the natural process of free fall.

Bacon, similarly, is seeking such ultimate explanations. What his method is designed to do is to provide a route to such explanations, and the route takes us through a number of proposed causal accounts, which are refined at each stage. The procedure he elaborates, eliminative induction, is one in which various possibly contributory factors are isolated and examined in turn, to see whether they do in fact make a contribution to the effect. Those that do not are rejected, and the result is a convergence on those factors that are truly relevant. The kind of 'relevance' that Bacon is after is, in effect, necessary conditions: The procedure is supposed to enable us to weed out those factors that are not necessary for the production of the effect, so that we are left only with those that are necessary.

15 Val. Term.: Works iii.236.

Bearing this in mind, let us return to the nature of Bacon's 'Forms'. In the *Advancement of Learning* and *De Augmentis*, he tells us that just as we should not seek the Forms of the sounds that make up words, so we should not seek the Forms of a lion, an oak, or even of water and gold, for these are infinite. Rather, we should inquire in the first case what the sounds making up letters are, a finite task, and then we will be able put these together and understand words. So too in the second case, what we should seek are the Forms of sense, colours, weight, density, heat, and so on: These are the 'true' Forms of things, and it is with these that we must be concerned.¹⁶ Forms are, then, the ultimate ingredients; but what kind of ingredients are these? Although there is some variation in the way in which Bacon characterises Forms, the Form of something seems to be, above all, its basic material structure, the way in which its constituent material parts are disposed. This is, of course, a traditional atomist conception; although, as we shall see, Bacon's matter theory, while it has much in common with traditional atomism, differs significantly from the kind of account we find in Lucretius, for example – not least in that it invokes various mechanical qualities such as elasticity and pressure in a basic explanatory role, and because Bacon's theory of the nature of matter is indebted to a complex chemical/alchemical theory about the fundamental kinds of matter.

There is what might seem a different conception of Forms, as laws, set out several pages later in *Novum Organum*:

When I speak of Forms, I mean nothing more than those laws and determinations of absolute actuality, which govern and constitute any given nature, as heat, light, weight, in every kind of matter and subject that is susceptible of them. Thus the Form of Heat or the Form of Light is the same thing as the Law of Heat and the Law of Light. (xvii: *Works* i.257–8/iv.146)

But all Bacon seems to be doing here is emphasising the causal/explanatory role of Forms: The Form is a necessary and sufficient condition for the manifestation of macroscopic properties it is invoked to explain. It is not just a particular disposition of the constituent material parts. Rather, it is the disposition of these parts that explains why the thing having these parts, disposed in this way, has the properties it has: for example, why it is solid, yellow, malleable, and so on. In other words, a genuinely basic disposition of constituent material parts acts in a completely regular, lawlike fashion. This lawlikeness is important because Bacon treats understanding the basic structures of things not as an end in itself, but as a means to transforming nature for human purposes: Lawlikeness is the crucial connection between our knowledge of basic structure and our ability to transform nature. Unless the basic structures of things

16 *Adv. Learn.*: *Works* iii.355–6; *De Aug.*: *Works* i.364–6/iv.361.

held a lawlike relation to the effects they underpin, knowledge of them would not be of any use to us.¹⁷

Simplicity, however, is just as central as lawlikeness, if Bacon's project is to succeed. This is evident in his twofold rule for the transformation of bodies. The first part involves grasping the simple natures that make up a body. He lists the simple natures of gold as yellowness, heaviness, malleability or ductility, lack of volatility, susceptibility to particular means of separation, and other unspecified natures. Someone who knows the Forms of these simple natures and who knows the method of superinducing them, Bacon tells us, will be able to join them together in some body and thereby produce gold (v: *Works* i.230–1/iv.122). The idea – one that is about as un-Aristotelian as imaginable – is that gold consists simply in a combination of particular properties, and that to reproduce those properties is to reproduce gold. There is an implicit assumption here not only that the simple natures are finite, but also that they are manageably small in number. However, there is also a second aspect to bodies, the grasp of which enables us to account for how bodies are formed in nature, how gold is formed not from simple natures but from other minerals, for example, or how the foetus is formed. Such processes are not to be understood by means of general laws of nature, but are related to 'particular and special habits of nature, not to her fundamental and universal laws which constitute Forms' (v: *Works* i.232/iv.123). At least part of Bacon's point here seems to be that, while it is necessary that we fathom the general laws of nature if we are to understand any natural process, there are many processes – the assimilation of food by the body, the production of voluntary motion in animals, and the production of articulate language in humans are the examples that Bacon gives – for which such a grasp is not sufficient. These are not emergent properties, in the sense of properties that come into existence only at a certain level of complexity or at a certain scale of magnitude; rather, the way in which Bacon talks about them indicates that they are simply the product of general laws and the combination of simple natures under very specific and precise initial conditions.¹⁸

17 I leave to one side here those peculiar cases where we might be able to perceive patterns in apparently nonlawlike events, as in the case of weather patterns.

18 Reserving the term 'metaphysics' for the grasp of general laws or 'eternal and immutable Forms', he suggests that 'the investigation of the Efficient Cause, and of Matter, and of the Latent Process, and the Latent Configuration (all of which have reference to the common and ordinary course of nature, not her eternal and fundamental laws) constitute *Physics*. And to these let there be subordinate two practical divisions: to *Physics*, *Mechanics*; to *Metaphysics*, what (in a purer sense of the word) I call *Magic*, on account of the broadness of the ways in which it moves, and its greater command over nature.' *Nov. Org.* II ix: *Works* i.235/iv.126.

This discussion is a prelude to the main business of Part II of *Novum Organum*, which is the setting out of the investigative procedures that must be followed if the kind of understanding – ‘interpretation’ – of nature that Bacon is seeking to be achieved. The aim is a twofold one, reminiscent of the *regressus* theory that had dominated discussions of method in the sixteenth century: to move inferentially from experience to first principles, and then to move inferentially from these first principles to new experiments. The first stage in realising this aim is to

prepare a *Natural and Experimental History*, sufficient and good; and this is the foundation of all; for we are not to imagine or suppose, but to discover, what nature does or may be made to do. (x: *Works* i.236/iv.127)

Although the point is not pursued here in *Novum Organum*, in the *Parasceve ad Historiam Naturalem et Experimentalem*, ‘Preparative to a natural and experimental history’, dating from 1620, Bacon urges that in compiling a natural history we must not follow the classical models – particularly Theophrastus, Dioscorides, and Pliny – and he urges that antiquities, descriptions of species, and ‘superstitious stories’ be avoided, as being a waste of time.¹⁹ Instead, we need to adopt a more focused and quantitative approach: ‘everything relating to bodies and virtues in nature should be set forth (as far as possible) numbered, weighed, measured, defined.’²⁰ In particular, guidelines for reporting are laid out: Things that are certain should be set down simply, things that are doubtful need to be prefaced by ‘it is reported that’, ‘they relate that’, or ‘I have heard from persons of credit that’, and it should be indicated whether one has witnessed the events oneself or taken a report from oral or written sources. Things one knows to be false, if still widespread, must be explicitly refuted so that they do no further damage.²¹ This is at least part of what he means when he urges that a ‘history’ of the kind he has in mind must be compiled and presented in a particular way if it is to be of any use, and for these purposes we need to compile ‘Tables and Arrangments of Instances’ which help prevent the understanding being ‘confounded and distracted.’

But even this is not enough, for even when this is done, still the understanding, if left to itself and its own spontaneous movements, is incompetent and unfit to form axioms, unless it be directed and guarded. Therefore in the third place we must use *Induction*, true and legitimate induction, which is the very key of interpretation. (x: *Works* i.236/iv.127)

19 *Parasceve: Works* i.396/iv.254.

20 *Ibid.*: *Works* i.400/iv.259.

21 *Ibid.*: *Works* i.401/iv.260.

Bacon then proceeds to an extended example of what he has in mind, the investigation of heat; but earlier, in *Valerius Terminus*, he had provided another example of his method, concerning the nature of colour, that is worth following through first, as it highlights clearly just what is involved in the procedure in a less elaborate way than in his treatment of heat.

Bacon's account of colour is presented as an alternative to Aristotle's. In *De anima* and *De sensu*, Aristotle had rejected the theories of his predecessors concerning light and vision: Light is not a corpuscular emanation from objects, he argued; neither does vision occur by means of a ray issuing from the observer's eye. This means he has to look for the key to vision in the nature of the medium, and his accounts of light, transparency, and colour depend crucially on properties of the medium intervening between the perceiver and the object perceived. There are three ingredients in his account of colour. First, there is the intervening medium, which has a property of transparency which can either be potential (as when it is dark) or actual. Second, light is a state of the medium in which transparency is actualised. Light is required for the third ingredient, colour, which modifies the properties of an actually transparent medium. Colour is that property of the surfaces of objects that has the ability to modify the transparent state of the medium. It 'moves' the transparent medium, which is continuous, and so acts upon the sense organ.²² Aristotle has arrived at his account by a mixture of a priori arguments – he had argued, for example, that atomist accounts of light simply reduce sensation to touch, that rays issuing from the observers' eyes leaves more unexplained than it explains, and so on – and various bits of observational information – objects touching the eye cannot be seen, light requires no time for its propagation, and so on. Bacon's account does not mention the details of Aristotle's, nor any of his criticisms of atomism – such as the criticism that, since it was generally accepted that light is propagated instantaneously, atoms would have to travel at infinite speed; nor, more important, does he engage with Aristotle at the level of where the nature of colour is to be found. He simply takes atomism/corpuscularianism as given, in the sense that it is in the microcorpuscular structure of the coloured body that the explanation is to be found, and the point is to guide us to the correct atomistic/corpuscularian explanation.

The method works by taking, as our starting point, some combination of substances that produces whiteness – that is, we start with what are in effect sufficient conditions for the production of whiteness – and then we remove from these anything not necessary for the colour. In the

22 Aristotle, *De anima*, 419A14–15.

first 'direction', we note that if air and water are mixed together in small portions, the result is white, as in snow or waves. This gives us sufficient conditions for whiteness, but not all and only the necessary conditions, for it is 'very particular and restrained, being tied but to air and water.'²³ So in the second direction, we increase the scope, substituting any transparent uncoloured substance for water, whence we find that glass or crystal, on being ground, become white, and albumen, which is initially a watery transparent substance, becomes white on having air beaten into it. In the third direction, we further increase the scope, and ask what happens in the case of coloured substances. Amber and sapphire become white on being ground, and wine and beer become white when brought to a froth. The substances considered up to this stage have all been 'more grossly transparent than air'. In the fourth direction, Bacon considers flame, which is less grossly transparent than air, and argues that the mixture of the fire and air makes the flame whiter. The upshot of this is that water is sufficient for whiteness, but not necessary for it. He continues in the same vein, asking next whether air is necessary for whiteness. In the fifth direction he notes that a mixture of water and oil is white, even when the air has been evaporated from it, so air is not necessary for whiteness, but is a transparent substance necessary? Bacon does not continue with the chain of questions after this point, but sets out some conclusions – namely, that bodies whose parts are unequal but in simple proportion are white, those whose parts are in equal proportions are transparent, while 'inequality in compound or respective order or proportion produceth all other colours, and absolute or orderless inequality produceth blackness.'²⁴ In other words, this is the conclusion that one might expect the method of sifting out what is necessary for the phenomenon and what is not to take, although Bacon himself does not provide the route to this conclusion here.

This being the case, one can ask whence his confidence in his conclusion derives, if he has not been able to complete the 'induction' himself. The answer is that it derives from the consequences he can draw from his account. There are two ways in which the justification for the conclusions can be assessed: by the procedure of eliminative induction that he has just set out, and by the consequences of those conclusions generated by it:

Out of this assertion are satisfied a multitude of effects and observations, as that whiteness and blackness are most incompatible with transparence; that whiteness keepeth light, and blackness stoppeth light, but neither passeth it; that whiteness or blackness are never produced in rainbows, diamonds, crys-

23 *Val. Term.: Works* iii.236.

24 *Ibid.: Works* iii.237.

tals, and the like; that white giveth no dye, and black hardly taketh dye; that whiteness seemeth to have an affinity with dryness, and blackness with moisture; that adjunction causeth blackness, and calcination whiteness; that flowers are generally of fresh colours, and rarely black, &c. All of which I do now mention confusedly by way of derivation and not by way of induction.²⁵

In short, there is a two-way process, from empirical phenomena to first principles, and then from first principles to empirical phenomena. This is a classic Aristotelian procedure. Where Bacon's version of it differs is in how the first step is carried out, and the difference turns on the use of eliminative induction.

Bacon's treatment of heat in *Novum Organum* follows essentially the same route, albeit in a more elaborate way. The first thing to do, he tells us, is to make a 'table' – an elaborate list if there ever was one – of 'instances agreeing in the nature of heat', that is, of those cases in which heat is present: the rays of the Sun, reflected rays, meteors, thunderbolts, volcanic eruptions, flame, burning solids, natural warm-baths, boiling liquids, hot vapours and fumes, fine cloudless days, air confined underground, wool and down, bodies held near a fire, sparks, rubbed bodies, confined vegetable matter, quicklime sprinkled with water, metals dissolved in acids or alkalies, the insides of animals, horse dung, strong oil of sulphur and of vitriol (i.e., sulphuric acid), oil of marjoram, rectified spirit of wine, aromatic herbs (which are hot to the palate), strong vinegar and acids (which burn those parts of the body where there is no epidermis, such as the surface of the eye), and finally intense cold, which can produce a burning effect (xi: *Works* i.236–8/iv.127–9). The list makes no claims to completeness, of course, but presumably what it does aim to do is to give us some idea of the range of phenomena with which we have to deal. Now since a Form should be not only present when the effect is present, but absent when the effect is absent, the next step, ideally, would be to list those cases where the effect was absent; but this is clearly an impossible task, for the list would be infinite. So what Bacon does is to list, in some detail, counterinstances to the items of the first list: when heat is absent, or at least where there is some doubt. So, for example, the rays of the Sun are hot but those of the Moon and the stars are not; the reflections of the Sun's rays are generally hot but not in the polar regions; the presence of comets (counting these as a type of meteor) does not result in warmer weather; and so on (xii: *Works* i.239–47/iv.129–37). The point of this exercise is not simply to create a 'table' of known counterinstances, however, but also to suggest experiments that need to be carried out to discover whether there are counterinstances – for instance, in the case of lenses and 'burning mirrors', in connection with which he makes several suggestions.

Instances and counterinstances of heat are absolute questions, but we can also discover something of the nature of heat by comparative means:

Thirdly, we must make a presentation to the understanding of instances in which the nature under inquiry is found in different degrees, more or less; which must be done by making a comparison either of its increase and decrease in the same subject, or of its amount in different subjects, as compared one with another. For since the Form of a thing is the very thing itself, and the thing does not differ from the Form except in the way that the apparent differs from the real, or the external from the internal, or the thing in reference to man from the thing in reference to the universe; it necessarily follows that no nature can be taken as the true Form, unless it always decrease when the nature in question decreases, and in like manner always increase when the nature in question increases. (xiii: *Works* i.247–8/iv.137)

This requires the compilation of a 'table of degrees or comparison', in which the instances previously listed are examined in respect of changes in heat. Putrefaction always 'contains' heat, for example; inanimate things are not hot to the touch, the heat of lower animals such as insects is barely perceptible, but higher animals are hot to the touch; the heat in animals increases as a result of motion; the heat of celestial bodies is never sufficient to set fire to things on Earth; the Sun and the planets give more heat in perigee than in apogee; and so on (xiii: *Works* i.248–56/iv.137–45).

It is at this point that induction comes into play. The various instances set out in the three 'tables' must be reviewed with a view to eliminating those natures which can be absent while heat is still found, those natures which are present even though heat is absent, and those where the heat increases or decreases without a corresponding increase or decrease in the nature (xvi: *Works* i.257/iv.145–6). Examples of the exclusions are: On account of the fact that the rays of the Sun sometimes warm and sometimes do not, reject the nature of the elements as the explanation for heat; on account of ordinary fire and subterranean fires, reject the nature of celestial bodies; on account of boiling water, reject light or brightness; and so on (xviii: *Works* i.259–60/iv.147–8). This process is less reliable than it might seem, for the exclusion of some simple natures and the narrowing down to others presupposes that we know what simple natures are, whereas in fact we do not know this; but the procedures followed thus far, Bacon believes, do allow us to advance finally to the interpretation of nature, or at least to the first version of that interpretation, which he refers to as 'the first vintage'.

It is a premise of Bacon's account that the Form that causes an effect must be present in every instance and absent in every counterinstance, but he also points out that it is more evident in some instances than in others. This is particularly so in the case of heat: The tables show that

hot things – such as flames and boiling water – are characteristically in rapid motion, and also that compression acts to put out a fire. The tables show, moreover, that bodies are destroyed or changed radically by heat, indicating that heat causes a change in the internal parts of the body and perceptibly causes its dissolution (xx: *Works* i.261–2/iv.149–50). Bacon concludes that heat is a species of the general genus of motion, but before examining what marks it out from other species of motion, he removes some ambiguities from the idea of heat. Sensible heat, for example, which is relative to individuals, not to the universe, is not heat properly speaking but the effect of heat upon the animal spirits. Furthermore, the communication of heat from one body to another is not to be confused with the Form of heat, for heat itself and the action of heating are two different things; nor is fire to be confused with the Form of heat, for fire is a combination of heat and brightness (xx: *Works* i.262/iv.150–1).

Having removed these ambiguities, we can turn to heat proper. A number of things mark it out as a distinctive species of motion. First, heat is a motion that causes bodies to expand or dilate ‘towards the circumference’ – that is, in all directions – as is evident in the case of vapours or air, liquids such as boiling water, and metals such as iron, which expand when heated. Cold has the opposite effect in all cases. The second distinctive feature is that heat, as well as being a motion to the circumference, is also a motion upwards. To determine whether the contrary holds in the case of cold, Bacon proposes an experiment in which a sponge soaked with cold water is placed at the bottom of one heated rod and at the top of another to determine whether one cools faster than the other; and he suggests that the one with the sponge at the top will cool the other end of the rod more quickly (xx: *Works* i.263–4/iv.152–3). The third characteristic is that heat comprises a variety of nonuniform motion, whereby small parts of a body are moved in different ways, some motions being checked, others proceeding freely, with the result that the body experiences a quivering and swelling motion, which is constantly subsiding. This is evident in flames and in boiling water. Moreover, where the motion is of the whole, such as a gas escaping from confinement at great pressure, we find no heat. Bacon maintains that cooling proceeds like heating, in a nonuniform way, although the absence of great cold on the Earth makes this phenomenon less evident (xx: *Works* i.264–5/iv.153–4). Finally, the fourth characteristic of heat as a species of motion is that it acts rapidly, for comparison with the effects of age or time on the corruption of bodies shows a similar result, corruption or dissolution of bodies, and the difference must lie in the rate at which the parts of the body are penetrated (xx: *Works* i.265–6/iv.154). The case of cold is not mentioned here, and, unlike the first three characteristics, it is not clear just what Bacon would want to establish in the

case of cold. He sums up by drawing two kinds of conclusion from this 'first vintage':

The Form or true definition of heat . . . [is that] *heat is a motion, expansive, restrained, and acting in its strife upon the smaller particles of bodies.* But the expansion is thus modified; *while it expands all ways, it has at the same time an inclination upwards.* And the struggle in the particles is modified also; *it is not sluggish, but hurried and with violence.* Viewed with reference to operation it is the same thing. For the direction is this: *If in any natural body you can excite a dilating or expanding motion, and can so repress this motion and turn it back upon itself, so that the dilation does not proceed equably, but can have its way in one part and is counteracted in another, you will undoubtedly generate heat.* (xx: Works i.266–7/iv.155)

This is only the first stage in the inductive process for Bacon, but it is the one that is both most novel and most problematic, so before we proceed to the other stages, it deserves greater scrutiny.

A method of discovery?

In particular, it is appropriate to ask just how far the process of eliminative induction gets us. After all, to go back to the case of colour, it is a giant leap, indeed a qualitative leap, from noting that a mixture of oil and water is white to the conclusion that Bacon seeks: namely, that those bodies whose parts are in simple proportion are white. Is it plausible to suppose that the continuation of the procedure would in fact get us to the conclusion? More particularly, the 'directions' that have been followed to this stage remain wholly at the macroscopic level, yet their continued application is supposed to guide us to the particular microcorpuscular internal structure of a body which makes that body white. This prompts three distinct questions: whether eliminative induction generates explanations, whether it genuinely involves a process that converges to a single cause or explanation, and why the process should take the form of an account of an underlying microcorpuscular structure.

On the first question, could anyone, including Aristotelians, resist the demand that, in seeking an explanation for a physical phenomenon, they sift through all the possibilities until they have found *the* cause? In fact, Aristotle may well have resisted this demand. The question turns on the relation between explanations and causes.²⁶ Although the Greeks generally did not separate questions of causality and explanation, disputes did arise as to which should be given priority: Cause would be

²⁶ See the discussion in Richard Sorabji, *Necessity, Cause and Blame* (London, 1980), especially Part I.

given priority if one was seeking to determine or ascribe responsibility for something; explanation would be given priority if one was trying to provide an account of all the relevant factors concerning how something came about, without necessarily wishing to apportion blame or responsibility. It makes a considerable difference which of these views we take. The Stoics, for example, maintained that the most important thing was to determine responsibility and, as a consequence, they viewed causes as being necessarily active. This view was supported by an analogy with the law, where the person deemed responsible for an offence was the person who had done whatever it was that resulted in the offence being committed. The physical analogue here is a body: A cause is a body which does something to bring it about that another body is affected in some way. On this construal, an explanation is simply a statement of a cause: Cause is prior to explanation. The alternative is to make explanation prior to cause, in which case we might say that a cause is whatever figures in the explanation of an event. Take the legal analogy: If we were seeking an explanation of why an offence occurred, rather than simply trying to find out who was to blame, we might look at all kinds of factors, such as the conditions under which offences of this kind usually occur, whether preventative measures had been taken, what kinds of things motivated people to commit offences of this kind, and so on. In natural philosophy, Aristotle makes explanations prior to causes. His famous 'four causes' are in fact four kinds of explanation, the combination of which is designed to yield a complete understanding of the phenomenon. If we know what something is, what it is made from, how it was made, and for what end it was made, we have a complete understanding of the phenomenon. To restrict oneself effectively to efficient causes, as Bacon does, will not yield such an understanding. So Aristotelians might well resist the notion that Bacon's procedure is going to lead to explanations.

Someone who is committed to making explanations prior to causes will argue that there are as many causes of something as there are explanations of that thing, for what will count as a cause will be determined by the kind of explanation one is seeking. It seems to me that Bacon has little in reply to this kind of move. In Chapter 13 of *Valerius Terminus*, he sets out the error of seeking the causes of particular things, which are 'infinite and transitory', as opposed to 'abstract natures, which are few and pertinent'. Such criticism seems most appropriately levelled against alchemists and others, whom Bacon criticises elsewhere for their piecemeal approach, rather than Scholastic natural philosophers, who would agree with his stricture here; but in fact Bacon has the Scholastics in mind, telling us that, despite appearances, on closer examination they do not seek abstract natures. This somewhat surprising criticism is possible only because of the very restrictive interpretation he

places on 'abstract natures', which he compares to 'the alphabet or simple letters, whereof the variety of things consisteth; or as the colours mingled in the painter's shell, wherewith he is able to make infinite variety of faces or shapes.'²⁷ Clearly, what he really wants is an atomist account of the 'abstract natures' of things, something which can be defended only on substantive natural-philosophical grounds. The kind of explanation he is seeking, namely an atomist/corpuscularian one, is without doubt guiding what is going to count as a satisfactory argument here.

This brings us to the second question: Is eliminative induction suitable as a method of discovering efficient causes? It is hard to see how it could not help in such a process, but it is far from clear that in itself it could generate an account of such causes. Indeed, it is impossible to see how Bacon's example of whiteness can be pursued further by eliminative induction to generate a conclusion of the kind he wants. One might admit some degree of convergence, but there is nothing like convergence to a point: Things become squared off well before that stage.

Somewhat surprisingly, given its origins in Bacon's matter theory, the strengths of an eliminative procedure become more evident when we are not searching for causes, and when we are concerned not with matter theory, but with mechanics. Indeed, the two great triumphs of mathematical physics in the first half of the seventeenth century – Galileo's establishment of the law of falling bodies and Descartes's establishment of the angle at which colours are formed when white light is refracted through a raindrop – can be seen in terms of an eliminative procedure; but once we examine these cases a little more closely, it becomes clear that eliminative induction is really playing, and can only play, a very minor role.

To establish the law of falling bodies, Galileo has to show what relations hold between a body falling in a void and that body falling in a resisting medium.²⁸ He takes the fall of bodies in a resisting medium as his starting point and then asks what factors are operative in determining the rate of fall of a body, and how these factors operate. The procedure is effectively an eliminative one. He shows first, contra Aristotle, that speed of fall cannot be proportional to absolute weight, since, among other things, two lead spheres of different weights dropped from

²⁷ *Val. Term.: Works* iii.243. Boyle will also use the idea of an 'alphabet of nature' in *The Origin of Forms and Qualities*, in *The Works of the Honourable Robert Boyle*, ed. T. Birch, 2d ed., 6 vols. (London, 1772), iii.298.

²⁸ See Galileo, *Two New Sciences*, trans. Stillman Drake (Madison, 1974), Third Day (140–213). See the discussion in my *Explanatory Structures: Concepts of Explanation in Early Physics and Philosophy* (Brighton, 1978), chap. 6.

a tower reach the ground at the same time. Nor can it be (inversely) proportional to the specific weight of the medium, for if we say that water is ten times denser than air, and take a body that falls in air but floats in water, such as cork, then if (assuming a uniform motion for the sake of simplicity) the cork has a rate of fall of 20 metres/sec. in air, it would follow from the Aristotelian account that it would have a rate of fall of 2 metres/sec. in water; but it does not fall in water at all. In response to this, Galileo suggests that the rate of fall might be a function of the specific weight of the body minus the specific weight of the medium. To see whether this is the case, he compares the fall of various bodies in various media, and finds that gold and lead fall at approximately the same rate in air, but this is not the case in mercury: One sinks in mercury whereas the other rises to the surface. So rate of fall cannot be a function of the specific weight of the body minus the specific weight of the medium. In fact, by comparing the rates of fall of ebony and lead in air and water, Galileo is able to show that the differences in the rate of fall of bodies is proportional to the specific weight of the medium divided by the specific weight of the body, and when the specific weight of the medium is zero, there can be no difference in rates of fall.

Now we can think of what Galileo is doing here in terms of eliminating various options: (1) the absolute weight of the body, (2) the specific weight of the medium, (3) the specific weight of the body minus the specific weight of the medium. But does 'eliminative induction' here amount to anything more than the commonplace that, if we have several possible explanations, one way that we can identify the right one is to eliminate the wrong ones? There is some skill in how the eliminations are accomplished, particularly in this case in Galileo, but the real skill, and what really drives the whole process, comes in identifying the possible explanations in the first place. The move from the absolute weight of the body to the specific weight, for example, comes from an appreciation of a fundamental problem in Aristotle's account: He is trying to quantify apparently incommensurable phenomena. He is saying that rate of fall is directly proportional to absolute weight and inversely proportional to the specific weight of the medium. But how do we compare absolute weight and specific weight? Galileo realises we must compare like with like: specific weights. Even more crucial is the move from comparing two bodies in the one medium or one body in two media to comparing n bodies in n media, that is, to the realisation that it is not the difference between specific weights but the ratio between them that is crucial. Eliminative induction cannot show us that. Moreover, note that Galileo does not use the procedure to show some underlying reality, some necessary condition of free fall, or even a cause of free fall, but that uniformly accelerated motion is the only universal component of motion in any instance of free fall.

In some ways of even more interest is the case of Descartes on the production of colour from white light in the *Dioptrique*.²⁹ Descartes is concerned to explain how colours are produced in the rainbow. He notes that the colour spectrum can be produced not only in the sky but also in fountains and showers in the presence of sunlight. This leads him to formulate the hypothesis that the phenomenon is caused by the reaction of light on drops of water. To test this, he stands with his back to the Sun and holds up in the sunlight a glass bowl filled with water, moving it up and down so that colours are produced, and noting the angles at which the primary and secondary bows are produced. Then in order to discover the path of the light ray through the water, he places a black sheet with a small opening at various points around the globe, noting at what angle the light must enter and leave the globe for the colours to be produced. Again, the procedure can be construed as an eliminative one, and here it must be admitted that the eliminative induction is doing a little more work than in the case of falling bodies; but, if we can draw a parallel with Bacon's account of whiteness, it proceeds in quite a different direction from that which we might expect Bacon to pursue. Having no interest in the geometry of the situation, we might expect him to have become stuck at the stage when Descartes realises that the sky is not a necessary condition for the production of the colour spectrum, and to have pursued the question of whether water is necessary by testing other clear liquids, generating much further work for eliminative induction but getting absolutely nowhere. In this respect it is worth noting that when Descartes tries to fill out his account of the production of colour in terms of his matter theory, he fares little better than Bacon. In his treatment of the production of colours through a prism, where he tries to show how light corpuscles passing through the prism can acquire a rotational velocity, which can be accelerated or retarded depending on how the corpuscles are packed against one another, and which is responsible for the colour spectrum, he has significantly less success than in his geometrical optics. He uses a similarly eliminative process, but the actual explanation involves a contentious picturing of the behaviour of light corpuscles which, while it does not involve anything like Bacon's huge leap from what his eliminative procedure yields to his proposed microcorpuscular explanation, does nevertheless require a leap – one which he cannot justify and which, more important, no eliminative procedure can bridge.

In sum, it is difficult to find a case where eliminative induction does real work, where the other factors are not the crucial ones in the process. Moreover, it seems particularly ill-suited to discovering the material

29 See the discussion in my *Descartes, an Intellectual Biography* (Oxford, 1995), 256–69.

constituents or causes of macroscopic phenomena. Bacon has elaborated something which is useful, and Aristotelians, at least to the extent to which they are concerned to discover efficient causes, must take it seriously; but its credentials as a method of discovery, as opposed to simply an aid, are quite impossible to establish.

Prerogative instances

Eliminative induction does not exhaust Bacon's account of a method of discovery by any means. In the account of heat in *Novum Organum* that we have considered up to now, all that Bacon considers to have been established in the steps pursued up to this stage is a basic understanding of heat, but we are far from having completed our investigation. We have only completed the first stage of the inductive procedure, and there are eight more to be pursued:

I propose to treat then in the first place of *Prerogative Instances*; secondly, of the *Supports of Induction*; thirdly, of the *Rectification of Induction*; fourthly, of *Varying the Investigation according to the nature of the Subject*; fifthly, of *Prerogative Natures* with respect to Investigation, or of what should be inquired first and last; sixthly, of the *Limits of Investigation*, or a Synopsis of all natures in the Universe; seventhly, of the *Application to Practice*, or of things in their relation to Man; eighthly, of *Preparations for Investigation*; and lastly, of the *Ascending and Descending Scale of Axioms*. (*Nov. Org.* II xxi: *Works* i.268/iv.155)

True to form, Bacon provides us only with details of the first of these, but the details he provides are extensive – they take up the remaining hundred pages of Book 2 – and if the next six were developed in the same detail, *Novum Organum* would more than triple in size.³⁰

The list of prerogative or privileged instances are designed to help one pick out the kinds of case most useful to one's investigation, and as such they serve very much the function of the topics, as conceived by Aristotle in a general context, and by his Renaissance followers as rhetorical guides. They are practical guides which enable one to seek out the most informative kinds of case, to avoid dead-ends, to collect the clearest and most unambiguous forms of evidence, and so on. Bacon lists twenty-seven such prerogative instances, and they give a good indication of the comprehensiveness of his project – and, undoubtedly, of why *Novum Organum* was taken so seriously in the succeeding two centuries. They show the different probative values, degrees of relevance, and heu-

30 This is on the assumption that the next six are designed to be included in later books of *Novum Organum*: From their titles, and from context, this seems a fair assumption. We must, however, exclude the last two, as the eighth belongs to the fourth part and the ninth perhaps to the sixth part of the 'Great Instauration.'

ristic values that different kinds of observation have, and are invaluable as a detailed account of observational and experimental practice, without precedent and unparalleled in detail and scope not only in Bacon's own time but since, surpassing the great nineteenth-century attempts to formulate an account of method in writers like Mill and Whewell. Moreover, unlike nineteenth- and twentieth-century accounts of method, Bacon's 'instances' are not a rational reconstruction, for the benefit of other scientists and philosophers, of how great scientists have proceeded, but suggestions that aim to guide scientific activity in a practical way. Here, nothing is too trivial to include if it is genuinely helpful, and nothing is too profound to exclude if it is not. The aim is not to prove a point but to provide guidance. Indeed, if the benefits of Bacon's legal training are anywhere evident in his natural philosophy it is here, for it is here that an appreciation of the sheer variety of investigatory approaches, and a thorough and balanced assessment of their relative value and standing, is crucial.

Bacon's claim at the end of the second book of *Novum Organum* is that his 'logic' is very different from 'common logic', in that it deals not with abstractions but 'dissects nature and discovers the virtues and actions of bodies, with their laws as determined in matter'; it 'flows not merely from the nature of the mind but also from the nature of things', and so it is no wonder that 'it is everywhere sprinkled and illustrated with speculations and experiments in nature, as examples of the art I teach.'³¹ His account of the prerogative or privileged instances shows he is quite justified in this claim, for just as nothing remotely comparable at the level of comprehension and practicality had appeared before, neither had there been an appreciation of the range of issues that needed to be covered if one was to guide natural philosophers in their inquiries. He deals with motivation, timesaving, and short cuts, no less than with what and how to measure, the differences between states of matter, how to deal with unobservables, how to approximate, and so on. This range comes not from reflection on traditional theories of logic and method, but from consideration of classical theories of rhetoric, from Aristotle, Cicero, and Quintilian on. It is in this area that one finds discussions of self-motivation and practical advice about short cuts incorporated seamlessly into the treatment of an abstract and theoretical questions. The only precedent is Aristotle's *Topics*, designed to offer instruction and guidance in all areas of cognitive endeavour, but the *topoi* had been treated subsequently as a guide only in rhetoric, and improved upon in the Roman rhetorical writers. Bacon, in a radical and brilliant departure from this tradition, uses the resources of rhetoric, supplemented by a detailed

31 *Nov. Org.* II lii: *Works* i.363/iv.246.

engagement with legal investigation, and presents a course not for rhetoricians or lawyers but natural philosophers.

Productive truth

Closely tied up with Bacon's account of method is his treatment of the question of truth. In *Valerius Terminus* he goes through a number of what he considers to be inadequate criteria that have been used to establish truth. He begins by telling us that 'in deciding and determining of the truth of knowledge, men have put themselves upon trials not competent', and he proceeds to set out the criteria that have been used which he finds unsatisfactory.³² The first of these is 'antiquity and authority', not a surprising inclusion, although a line needs to be drawn between the excessive respect for antiquity and authority that one encounters in Scholastic writers, and the complete lack of any sense of authority that one encounters in the zealotry of the radical puritans. He rejects two criteria which might conflict with antiquity and authority, namely 'common and confessed notions' and 'the natural and yielding consent of the mind'. The latter represents a rejection of a tradition of thinking about the internal evidence for the veridicality of our ideas which stretches from Aristotle and Quintilian up to the seventeenth century,³³ a tradition in which one inspects one's ideas with regard to their vividness, particularity, and clarity, as an indication of their reliability. Next Bacon rejects criteria that rely upon the internal consistency or the capacity for internal reduction of theories, presumably on the grounds, among others, that such criteria do not bear on the question of whether there is any correspondence between the theory and reality. He also rejects 'inductions without instances contradictory; and the report of the senses'. These, he tells us, are not 'absolute and infallible evidence of truth, and bring no security sufficient for effects and operations.' That he ties in evidence for the truth of a theory and its usefulness here is no accident, for these are intimately connected:

That the discovery of new works and active directions not known before, is the only trial to be accepted of; and yet not that neither, in case where one particular giveth light to another; but where particulars induce an axiom or observation, which axiom found out discovereth and designeth new particulars. That the nature of this trial is not only upon the point, whether the

32 *Val. Term.: Works* iii.242.

33 I have argued that Descartes, drawing on Quintilian's account, but giving it a radical twist, operated with such a criterion in the 1620s. See my 'Descartes' Early Doctrine of Clear and Distinct Ideas', originally published in *Journal of the History of Ideas* 53 (1992), 585–602, now reprinted in my *The Genealogy of Knowledge* (Aldershot, 1997), 131–52.

knowledge be profitable or no; not because you may always conclude that the Axiom which discovereth new instances be true, but contrariwise you may safely conclude that if it discover not any new instance it is in vain and untrue. (*Val. Term.: Works* iii.242)

Is Bacon providing a gloss on truth here, maintaining that it has been misconstrued, that to say something is true is exactly the same as saying that it is useful? Or is he saying that something is true, in the ordinary accepted sense, only if it is useful? Whichever, it is a very strong claim on Bacon's part. Are there no useless truths, and are there no falsehoods which have practical application? It is not simply that false premises may lead to true conclusions, but there are cases where approximations, which while false, may have more practical value than the truths they approximate.

We can gain some clarification here by considering the debates on the types of knowledge to be gained by different forms of reasoning. These debates are complex and often obscure,³⁴ but the issue in which we are interested is clear enough, and it takes its origins from a question in the *Posterior Analytics* wherein Aristotle asks about the conditions under which the syllogism can generate informative conclusions. The problem for those concerned with questions of method was how it is possible to move inferentially from observed phenomena (effects) to the underlying proximate cause, and then to 'demonstrate' the observed phenomena from the underlying proximate cause, without this being simply circular. The idea was that the inferential procedure can avoid circularity if, at the start of the process, we have knowledge *that* something is the case, whereas at the end of it we have knowledge *why* it is the case. In other words, the kind of knowledge of an observed phenomenon we have through sensation is qualitatively different from, and inferior to, the kind of knowledge we have of that phenomenon when we grasp it in terms of its causes. Aristotle himself had tried to provide an account of the demonstrative syllogism which distinguished procedures which were epistemically informative from those which were not, and he realised that the difference could not be captured in purely logical terms. What he was seeking, what the Stoics had been seeking, and what both Aristotle's Renaissance followers (the radical Paduan commentators such as Nifo and Zabarella, as well as the more conservative Coimbra commentators) and his detractors (such as Ramus) were seeking, was

34 The literature is vast, but see Neal W. Gilbert, *Renaissance Concepts of Method* (New York, 1960); John H. Randall, *The School of Padua and the Emergence of Modern Science* (Padua, 1961); Nicholas Jardine, 'Galileo's Road to Truth and the Demonstrative Regress', *Studies in History of Science* 7 (1976), 277–318; and my *Cartesian Logic* (Oxford, 1989).

not simply some means of generating truths, but some means of generating informative truths.³⁵

This is, I suggest, also what Bacon was seeking. If we think in terms of 'informative truths', Bacon's position makes a little more sense. He is saying that the only way in which we can judge whether something is informatively true is to determine whether it is productive, whether it yields something tangible and useful; and if something does consistently yield something tangible and useful, then it is informatively true.³⁶ Bacon formulates this issue in terms which are quite traditional, and if one simply confines one's attention to the question of informativeness, it is easy to see his project as working within much the same parameters as those of Aristotle and Ramus, while offering a rather different solution. There is another question, however, namely the 'abstract natures' that the ultimate truths of natural philosophy capture. As we have seen, in *Valerius Terminus*, Bacon insists that the 'abstract natures' that are the ultimate outcome of natural-philosophical investigation must be construed in atomist/corpuscularian terms. The question of the appropriate 'abstract natures' raises different kinds of issues, quite alien to Ramus's concerns, and diametrically opposed to Aristotle's substantive natural-philosophical doctrines. It was common ground that formal, deductive modes of reasoning do not yield informative truths, and that what was needed was something that did yield them; but there was also the question of what informative truths were like: In what does their informativeness consist, what kind of thing do they tell us, how do we distinguish genuinely informative from superficially informative truths?

Two factors are important here: the practical nature of such truths and, in the context of natural philosophy, the fact that they lead us to a level of physical activity which is genuinely fundamental, in that it can be used to explain why macroscopic physical processes occur in the way they do, but is not itself explicable in more fundamental terms. The former Bacon takes to be the sure sign, the only sign, of genuinely infor-

35 See my *Cartesian Logic*, which deals with these questions in some detail. Parallel considerations held in the case of mathematics, where mathematicians were often concerned with informative proofs, that is, proofs which demonstrated the conclusion in a way that showed the source of the conclusion, rather than just showing that the conclusion held. On these questions, see Paolo Mancosu, *Philosophy of Mathematics and Mathematical Practice in the Seventeenth Century* (New York, 1996).

36 The 'consistently' here is important if we are to be able to rule out cases where false premises just happen on particular occasions to yield true conclusions, for we can assume (for these purposes) that, unlike truths, they will not continue to do this indefinitely. The case of approximations can perhaps be dealt with by saying that these derive their usefulness not from their falsity but from their proximity to the truth, although the cases where the approximation is more useful than the true account cannot be handled so easily.

mative truths. The second hinges on Bacon's commitment to atomism/corpuscularianism, which is a more complex issue. Certainly he believes that an atomistic understanding of natural phenomena will enable one to engage with nature at a practical level, enabling one to transform nature in quite radical ways; but we should not ignore a more general form of atomism which is methodological rather than natural-philosophical. Such atomism relies on the notion of 'analysis', the breaking down of questions into more fundamental terms, into simple constituents, so that one can then recombine the constituents into something new. In the later sixteenth and seventeenth centuries, this was seen as a fundamental and wholly general process of discovery. The procedure was certainly to yield benefits in mathematics,³⁷ but its appeal was often quite universal, and it is, for example, an important part of Ramus's reform of rhetoric that language be analysed into the smallest significant units so that they can then be recombined.³⁸ Analysis, widely seen as the answer to the question of a method of discovery, led to a form of methodological atomism which, while it certainly did not require a commitment to physical atomism, must surely have been seen as a natural concomitant of physical atomism to those already committed to it. That Bacon is no exception here is indicated by his talk of the 'alphabet of nature', the Ramist overtones of which may not be wholly accidental.

We must distinguish two issues here. As I have said, it was common ground that formal, deductive modes of reasoning do not yield informative truths and that what was needed was something that did yield informative truths. Here Bacon's concerns mirror those of his predecessors, although his solution, in which his account of eliminative induction plays a major role, is new. However, the aim of the natural philosopher, on Bacon's view, is not merely to discover truths but to produce new works. This is something which goes beyond the idea that truth simply be informative. Here, not just Bacon's answers, but the way in which he sets up the question, are novel and distinctive, at least with respect to the philosophical tradition.

One commentator who has raised the question of just what guides Bacon's thinking on the connection between truth and works is Pérez-Ramos, who argues that Bacon (tacitly) employs a maker's knowledge conception, whereby knowing something and being able to make that thing are effectively the same.³⁹ But if one compares thinkers who do op-

37 On the appeal of analysis in mathematics, see Michael Sean Mahoney, *The Mathematical Career of Pierre de Fermat, 1601–1665*, rev. ed. (Princeton, 1994), chap. 2.

38 See Walter J. Ong, *Ramus, Method and the Decay of Dialogue* (Cambridge, Mass., 1983), chap. 11, esp. 263–7.

39 Antonio Pérez-Ramos, *Francis Bacon's Idea of Science and the Maker's Knowledge Tradition* (Oxford, 1988).

erate with a maker's knowledge conception (e.g., Hobbes, Locke, and Vico) with Bacon, what is at stake seems quite different. The maker's knowledge principle is a way of delivering certainty in areas which might seem to offer no hope of certainty – political and moral philosophy – and, as a result, these are typically raised above natural philosophy in terms of the degree of certainty attainable.⁴⁰ None of these considerations are present in Bacon, who is not concerned so much with the degree of certainty of results in natural philosophy (he has no time for scepticism in this regard, for example), but in making natural philosophy informative and productive.

It seems to me that we need to take fuller account of the question of what kinds of resources Bacon might have been drawing on in developing his conception of natural-philosophical knowledge. In the humanist thought from which Bacon derives much of his inspiration, moral philosophy figures very predominantly. Now in this philosophy, as we have seen, being virtuous and acting virtuously are the same thing: There is no separate practical dimension to morality. This is all the more interesting because moral philosophy is a cognitive enterprise, one in which the practical outcome is constitutive of the discipline, something Bacon stresses in the *Advancement of Learning*.⁴¹ If we see natural philosophy as being in some respects modelled on moral philosophy, something which is natural enough in a humanist context, and which is reinforced in the shift from *otium* to *negotium*, then we may be able to make more sense of the idea that truth is not truth unless it is informative and productive. If we think of Bacon's project as transforming moral philosophers into natural philosophers, then we might expect some carry-over from conceptions of the moral philosopher. Notions which were quite appropriate in moral philosophy, but not (at least outside Epicureanism) in natural philosophy, would remain in the transformation process. This, in fact, is exactly what we do find, most strikingly in the idea of truth as productive and informative. For Bacon, natural-philosophical truth is no more truth, if it is not informative and productive of works, than is moral truth. 'In religion', he tells us in *Redargutio Philosophiarum*, 'we are warned that faith is to be shown by works', quoting Luke 6.44: 'By their fruits ye shall know them.' And he proposes that the same test that is applied in religion be applied in philosophy: If it produces nothing at all – or, worse, if 'instead of the fruits of the grape or olive, it bear the thistles and thorns of disputes and contentions' – then we can reject it.⁴²

40 See my 'Vico and the Maker's Knowledge Principle', *History of Philosophy Quarterly* (1986), 29–44, reprinted in *Genealogy of Knowledge*, 224–41.

41 *Adv. Learn.* II: Works iii.432–4.

42 *Redarg.*: Works iii.576/Farrington, *Philosophy of Francis Bacon*, 123–4.

The institutional setting

The project that Bacon sets out requires a large-scale co-ordinated workforce. He does not offer a theory of method as something that any individual who wants to proceed in natural philosophy must follow. As indicated by the institutional reforms and radical purging of the mind that are required for overcoming, respectively, the external and internal impediments, what is at stake is the transformation of a whole mentality, not a recommended procedure which any individual might follow. Method is not something directed towards the individual as such, but rather something in which a large-scale co-operative workforce must be trained. This is, indeed, a crucial ingredient in the ability of natural philosophy to be 'productive of new works', for such new works are explicitly things of systematic benefit to the nation, not individual one-off discoveries.

Bacon indicates the magnitude and institutional nature of the project clearly at the beginning of the *Parasceve*:

For a history of this kind, such as I conceive and presently describe, is a thing of very great size, and cannot be executed without great labour and expense; requiring as it does many people to help, and being (as I have said elsewhere) a kind of royal work. It occurs to me therefore that it may not be amiss to try if there be others who will take these matters in hand; so that while I go on with the completion of my original design, this part which is so manifold and laborious may even during my life (if it so please the Divine Majesty) be prepared and set forth, others applying themselves diligently to it along with me; the rather because my own strength (if I should have no one to help) is hardly equal to such a province. For as much as relates to the work itself of the intellect, I shall perhaps be able to master that by myself; but the materials on which the intellect has to work are so widely spread, that one must employ factors and merchants to go everywhere in search of them and bring them in. Besides I hold it to be somewhat beneath the dignity of an undertaking like mine that I should spend my own time in a matter which is open to almost every man's industry. (*Works* i.393–4/iv.251–2)

It is no exaggeration to say that his project of setting out a programme for a state-run enterprise was one of vast proportions. Just how vast became increasingly clear as his work progressed. He was quite right that a single person could not possibly achieve these ends, and that was, after all, the price one paid for shifting natural philosophy out of the realm of arcane knowledge into the public domain. Others were well aware of this fact in the seventeenth century. In 1663, for example, Samuel Sorbière, in a passage that could be straight out of Bacon, noted:

To imagine that we might erect in this house a Shop, a Forge, and a Laboratory, or to put it in a word, build an Arsenal of machines to perform all sorts of experiments, is not possible at all, and is not the proper undertaking of a

few private persons. . . . Only Kings and wealthy Sovereigns, or a few wise and prosperous Republics, can undertake to set up a physical academy; where everything would pass in continual experiments. Palaces must be built to order; there must be numerous hired craftsman; there must be a considerable fund for expenses.⁴³

The problem was how one secured support for such reforms. Bacon did make efforts to attract support for his programme. Following the publication of the *Advancement of Learning*, for example, he seems to have lobbied various senior figures.⁴⁴ The *Advancement* had the misfortune to appear at the same time as the discovery of the Gunpowder Plot, which focused the minds of the king and his government on other matters. Nonetheless, even without this setback, it does seem unlikely that James was even prepared to consider something of the kind proposed by Bacon. In the absence of interest from the king, Bacon contemplated other means of realising his programme. Diary entries from July 1608 indicate that at one stage he thought about bypassing James altogether: He considers seeing if he could have the prince, Henry – who had a predisposition to scientific subjects and whose patronage was correspondingly sought by a number of mathematicians⁴⁵ – groomed for the task,⁴⁶ and he dedicated the 1612 edition of his *Essayes* to Henry. He also considers taking charge of things himself, by ‘layeng for a place to comānd wyttys and pennes’, that is, getting himself appointed to run an educational institution – in which connection he mentions Westminster, Eton, and Winchester, Trinity and St. John’s Colleges, Cambridge, and Magdalen College, Oxford.⁴⁷ In another of the diary entries from July 1608, Bacon considers ‘proceeding wth ye translation of my book of Advancem^t of learnyng’,⁴⁸ presumably with a view to securing a reading in continen-

43 Cited in Harcourt Brown, *Scientific Organizations in Seventeenth-Century France (1620–1680)* (Baltimore, 1934), 127. A good example of the relation between state investment and natural philosophy in the seventeenth century is the case of Johann Joachim Becher and the Habsburg court, discussed in Pamela H. Smith, *The Business of Alchemy: Science and Culture in the Holy Roman Empire* (Princeton, 1994).

44 Copies were sent to the Earl of Northampton, for the king, to Sir Thomas Bodley (diplomat, scholar, and founder of the library which bears his name), the Earl of Salisbury (a key figure among James’s advisers and chief minister from 1608), Lord Buckhurst (scholar, poet, and, by this time, Treasurer), and the Lord Chancellor. The accompanying letters survive and are given at *Works* x.252–5.

45 See Mordechai Feingold, *The Mathematicians’ Apprenticeship: Science, Universities and Society in England, 1560–1640* (Cambridge, 1984), 200–1.

46 *Works* xi.63.

47 *Works* xi.66. He will petition, unsuccessfully, to be appointed Provost of Eton after his disgrace in 1621. See *Works* xiv.407, 421, 428, 451.

48 *Works* xi.64.

tal Europe; but this also came to nothing in the middle term, the translation not appearing for another fifteen years. Finally, he compiles a list of possible patrons, experimentalists, and so on who might be in a position to enable work to be started on his programme. These included Sir Thomas Russell, an alchemist/chemist who published a tract on precious metals, *Diacatholicon Aureum*, in 1602, and who was a rare case of someone who was actually pursuing a government-supported scientific programme, namely the separation of silver from lead ore. Also included is Sir Thomas Chaloner, author of a short practical tract, *A short Discourse of the most rare Vertue of Nitre* (London, 1584), discoverer of alum deposits in England,⁴⁹ and governor of the house of Prince Henry. Bacon had been in correspondence with Henry Percy, the ninth Earl of Northumberland (the 'wizard Earl', as he was known, on account of his interest in alchemy), since 1603, and he was the most important patron of natural philosophy in England at this time. The circle Northumberland built up around himself had some of the greatest mathematicians and natural philosophers of his age – Thomas Harriot, Robert Hues, Walter Warner, Robert Norton, Nathanael Torporley, Thomas Allen, Nicholas Hill – as well as Sir Walter Raleigh.⁵⁰ Northumberland is included in the list, as are Harriot and Raleigh. Bacon also included three court physicians, Leonard Poe, John Hammond, and Sir William Paddy, and two well-placed clergymen, Richard Bancroft, Archbishop of Canterbury, and Launcelot Andrews, Bishop of Chichester and a favourite of the king.⁵¹ There is no evidence that Bacon ever actually approached any of these individuals, however, and this is perhaps indicative of his inability to mobilise support for the project.

Despite his closeness to James I, and his dogged persistence in trying to obtain a hearing for his projects, they were never taken seriously by the monarch or his advisers, or by anyone else in a position to realise them. Nor is there any evidence of the slightest enthusiasm from fellow natural philosophers; indeed, he seems to have been largely marginal-

49 This was a very profitable discovery, since this was at a time when exports from the papal mines at Tolfa were banned in England. Alum was crucial for the dyeing processes of the textile industry, and most of the alum from Tolfa was exported to the Netherlands. Alum export effectively kept the Papal States solvent between 1550 and 1650, when deposits began to dry up.

50 On this group, see Hugh Kargon, *Atomism in England from Harriot to Newton* (Oxford, 1966), chaps. 2–4.

51 It might seem surprising that Harvey is missing from the list, but his important work was yet to come and he was, in any case, a committed Aristotelian, although *De Motu Cordis* begins with the statement that he professes 'both to learn and to teach anatomy, not from book but from dissections; not from the positions of philosophers but from the fabric of nature' (*The Works of William Harvey*, trans. Robert Willis [London, 1847], 7), a sentiment of which Bacon could only have approved.

ised from them, with William Harvey, for example, evidently holding a low opinion of Bacon's talents.⁵² Why did Bacon's projects receive no support? The short answer is that he did not himself have much idea what might be involved at the organisational level. When he writes, as he often does, about building up an observational/experimental base in natural philosophy, there is no evidence of any clear idea of just how the tasks are to be funded and allocated, or just how the benefits of his proposals might be delivered. This, I believe, must have been clear to anyone considering his proposals, and it must be remembered that what he is recommending is an extremely expensive programme designed to be sponsored by the state. Bacon defends himself in this respect by maintaining that a small portion of the limitless expenditure at the time on useless objects and pursuits would suffice for his 'sane and solid' purposes;⁵³ but this surely serves only to draw attention to the expense of what he has in mind.

What is most striking about his proposal, however, is the fact that the only precedent he offers for his scheme is an interpretation of Solomon's House, which is in effect wholly imaginary. This is very surprising, since there were at least two recent and real precedents. The first was Gresham College, established in London in 1597, which offered free teaching, in English and Latin, on a range of practical scientific and mathematical subjects.⁵⁴ At the level of teaching, it must be admitted that Gresham College faced significant difficulties, and was not a great success, even though it was originally envisaged very much as a teaching institution; but it had a considerable reputation, and it was the most important centre of scientific research in areas such as the practical mathematical disciplines and chemistry/alchemy, providing a meeting place for those committed to the advancement of science.⁵⁵ Bacon never even mentions

52 Harvey apparently shared James's low view of the 'Great Instauration', remarking (according to Aubrey) that Bacon 'wrote philosophy like a Lord Chancellor', by which he seems to have meant that Bacon believed that one should follow the leadership of official experts and centralised organisations: See Julian Martin, *Francis Bacon, the State, and the Reform of Natural Philosophy* (Cambridge, 1992), 172. Nevertheless, in his *Exercitationes de generatione animalium* of 1651, Harvey does begin to make use of some Baconian notions. On Harvey's attitude to Bacon, see Roger French, *William Harvey's Natural Philosophy* (Cambridge, 1994), 325–8.

53 *Cog. & Vis.: Works* iii.616–17/Farrington, *Philosophy of Francis Bacon*, 98.

54 On Gresham College, see E. G. R. Taylor, *The Mathematical Practitioners of Tudor and Stuart England* (Cambridge, 1954); D. W. Waters, *The Art of Navigation in England in Elizabethan and Early Stuart Times* (Greenwich, 1978); I. Adamson, 'The Administration of Gresham College and Its Fluctuating Fortunes as a Scientific Institution in the Seventeenth Century', *History of Education* 9 (1980), 13–25; and John Ward, *The Lives of the Professors of Gresham College* (London, 1740).

55 See Feingold, *Mathematicians' Apprenticeship*, chap. 5.

the college, despite the fact that it was endowed by his uncle, Sir Thomas Gresham, in his will.⁵⁶ The second precedent was not in England, but it was one with which James was personally familiar: Uraniborg. Even though Bacon shows some acquaintance with Brahe's geoheliocentric theory,⁵⁷ he was apparently unaware of his observatory-laboratory complex, Uraniborg, on the island of Hven. At Uraniborg, Brahe was able to compile just about the most comprehensive and perfect set of observational data possible by the naked eye (i.e., by people chosen on the basis of their exceptionally good eyesight and trained to make accurate observations). It was a veritable scientific institution, with a purpose-built observatory, a skilled workforce, and routinised daily scientific work.⁵⁸ If there existed a practical example of what Bacon was recommending, this was it. Not only was it by far the closest thing in existence to his own proposals, bearing many resemblances to his plan for a Solomon's House, but James himself, whom Bacon wants to put his programme into practice, had visited it in 1590 and spent some hours in conversation with Brahe, as I mentioned early in Chapter 3. Bacon is ignorant of what had been achieved at Uraniborg or at Gresham College, and how it had been achieved – how staff had been chosen and trained, how projects had been funded, how material had been published – and he has no practical understanding of just what is involved in providing a comprehensive observational base for a discipline. Worse, it is evident he has no interest in developing such a practical understanding: His project is defended on the basis of a combination of criticisms of particular natural philosophies, and schemes for the reform of natural philosophy derived from first principles.

It must be said that this also reflects his approach to the details of natural philosophy. His income in 1608 was £4,975, and his own estimate

56 Gresham, a merchant banker and financial agent to the queen, had married the sister of Nicholas Bacon's first wife, Jane, and was a close colleague of Bacon's father. However, the bequest to Gresham College meant that the Bacon family was deprived of his very significant inheritance: See Lisa Jardine and Alan Stewart, *Hostage to Fortune: The Troubled Life of Francis Bacon 1561–1626* (London, 1998), 38.

57 Bacon's acquaintance with Tycho's work was very basic. He mentions Tycho and his geoheliocentric theory in *Descriptio Globi Intellectualis*: BW viii.112, 120, 132. But Rees's notes to this edition (387, 393), which show parallels between Bacon's phrasing and that of Patrizi, raise the possibility that he may have been familiar with the doctrine not first-hand but through the section entitled 'Pancosmia' in Patrizi's *Nova de Vniuersis Philosophia* (Venice, 1593).

58 See Victor E. Thoren (with contributions by John R. Christianson), *The Lord of Uraniborg: A Biography of Tycho Brahe* (Cambridge, 1990), chaps. 4–6. See also Jole Shackelford, 'Tycho Brahe, Laboratory Design, and the Aim of Science', *Isis* 84 (1993), 211–30.

of his assets was £24,155.⁵⁹ As Farrington has pointed out, if what Bacon wanted to do was to set up a private laboratory and start experimenting himself – as Boyle will do, for example – there was now nothing to stop him;⁶⁰ but he never even seems to have envisaged doing this. And it is particularly noteworthy that his correspondence, which is of a significant size, contains no discussion of natural-philosophical questions, in stark contrast to every other natural philosopher of the age.⁶¹ He seeks out no information from others, nor supplies any.⁶²

The lack of any practical sense of how one might set up a large-scale communal investigation in natural philosophy is nowhere more evident than in his scientific utopia, *New Atlantis*. We are given particulars of everything from the placing of windows in the streets to the dress of the Fathers of Solomon's House, right down to the colour of their underwear (white); but we are given no details of any of the mechanisms by which political and civil processes operate. This is especially problematic in the case of the organisation of Solomon's House: No details are forthcoming on how the work is organised, how people are trained, how tasks are allocated, how the House is financed, or what role the sovereign has.⁶³ Despite his immense political and administrative experience, Bacon has no real idea how one might proceed in the organisation of natural philosophy at a national level.

59 *Works* xi.81–8. By 1618, Bacon had a personal staff of around one hundred, vast by any standards – for details see Jardine and Stewart, *Hostage to Fortune*, 417–18 – and certainly of a scale to allow him to pursue a range of experimental natural-philosophical enterprises, along the lines that Boyle will follow some forty years later.

60 Farrington, *Philosophy of Francis Bacon*, 47.

61 Taking just figures of comparable stature, Galileo's and Descartes's scientific correspondence is very significant, for example. Indeed, correspondence was the principal form of scientific communication in an age lacking academies, journals, and conferences, and Mersenne, for example, made it his prime contribution to natural philosophy: *Correspondance du P. Marin Mersenne, religieux minime*, ed. Cornelius de Waard, R. Pintard, B. Rochot, and A. Beaulieu, 17 vols. (Paris, 1932–88).

62 Bacon did nevertheless have one source of information about recent scientific work: In his capacity as Attorney-General and then Lord Keeper, he oversaw every patent under consideration before 1620. See Webster, *Great Instauration*, 343–4.

63 One of Leibniz's principal criticisms of works like Johann Valentin Andreae's *Reipublicæ Christianopolitanæ Descriptio* (Strasbourg, 1619) and Bacon's *New Atlantis* was that they gave no idea how these societies had come into existence: They skipped over the process of continuous change that progress consists in, implied that progress might come to an end, and, even worse, encouraged the belief that rebellion might be a practical solution to political problems. See Ayval Ramati, 'Harmony at a Distance: Leibniz's Scientific Academies', *Isis* 87 (1996), 430–52.

Dominion over nature

Matter theory and natural philosophy

In Chapter 5 we saw that Bacon's account of method is closely tied to his advocacy of matter theory as the foundational natural-philosophical discipline. His natural-philosophical interests range across what we might now think of as cosmology, chemistry/alchemy, and physiology, and we can consider the means by which natural philosophy was pursued in these three areas in the seventeenth century in terms of two fundamental disciplines, mechanics and matter theory. The first deals with physical processes in terms of the motions undergone by bodies and the nature of the forces responsible for these motions. The second deals with how the physical behaviour of a body is determined by what it is made of, and in the seventeenth century it typically achieves this in a corpuscularian fashion, by investigating how the nature and arrangement of the constituent parts of a body determine its behaviour. Traditionally, matter theory had been constitutive of natural philosophy, and it was generally assumed from the Presocratics up to the seventeenth century that the key to understanding physical processes lay in understanding the nature of matter and its behaviour, whether this understanding took the form of a theory about how matter is regulated by external immaterial principles, internal immaterial principles, or by the behaviour of the internal material constituents of macroscopic bodies.

Around the beginning of the seventeenth century, however, there was an attempt to draw on the traditional disciplines of practical mathematics – geometrical optics, positional astronomy, harmonics, and statics were the best developed – and to incorporate these into natural philosophy. In particular, there was an attempt to devise a form of mechanics which relied on kinematics and ultimately delivered an account of the forces responsible for motions of various kinds. In pursuing this kind of approach, mechanics and matter theory became separated by the end of the seventeenth century, with Newton accounting for the structure of the cosmos in terms of mass points moving through an empty space regulat-

ed only by gravitation and inertia. In other words, in Bacon's first area of concern, cosmology, mechanics takes over from matter theory, and it does so at an early stage: in Kepler and Galileo. Moreover, it is notable that even when attempts are made to integrate mechanics and matter theory, as in Descartes's account of the stability of planetary orbits in *Le Monde*, the tasks of matter theory are essentially dictated by mechanics and optics, for it is mechanics and optics which determine how many different types of matter there must be and what kinds of properties they must have.¹ Bacon's cosmology is driven solely by matter theory, as we shall see, putting him completely at odds with just about every one else (Leibniz being the only significant exception) whom one would pick out as being at the forefront of natural philosophy in the seventeenth century.

The situation in chemistry/alchemy was rather different. Here matter theory remained crucial, although many of those who worked in this area, such as Boyle and Hooke, did attempt to mechanise matter theory in the sense of stripping matter of many of its traditional active powers and making it subject to mechanical laws. In these cases, mechanics begins to direct the programme of matter theory. Bacon works in the opposite way. In his earlier writings there is some discussion of motion as being in some way independent, within the context of a general matter theory, but later on he abandons even this, and motion becomes completely subordinated to matter. The situation in physiology was different again. Physiology was generally thought of in terms of matter theory, which was here supplemented with an account of various kinds of spirit whose presence was supposed to mark out vital from inorganic processes, and in some cases were supposed to account for sentience. There were attempts to mechanise physiology, beginning with Descartes, although these were always treated with great suspicion, and serious attempts to follow up the Cartesian programme of mechanising physiology had to wait until the eighteenth and particularly the nineteenth centuries.

Bacon pursues cosmology, chemistry/alchemy, and physiology in terms of matter theory, taking the second as the most fundamental area. To understand his enterprise, we need to put matter theory into context, for although some attention has been paid to the role of matter theory in developing a chemical theory, its broader role in early-modern natural philosophy as a whole has not been sufficiently understood or appreciated, and there has been a general assumption that the speculative matter theory that predates Boyle (who at least can be seen as having made a contribution to the early development of chemistry), while of philosophical interest, is of marginal significance to the direction in which the

1 See my *Descartes, an Intellectual Biography* (Oxford, 1995), 228–37.

Scientific Revolution moves. This is not the case, however, and matter theory is a fundamental part of natural philosophy, whose importance far outweighs any contribution it may have made to chemistry.

The interaction between matter theory and cosmology brings this significance out well. Bacon offers a thoroughly matter-theoretic cosmology, something quite different from the Copernican approach. Matter theory has generally been regarded as a poor cousin to Copernicanism in the shaping of early-modern natural philosophy, but this is in many respects a misleading picture of what actually occurred.² Copernicanism was taught and studied quite extensively in the sixteenth century, and its comparative mathematical simplicity was widely appreciated, but the idea that heliocentrism might express a plausible physical claim about the actual structure of the cosmos was either ignored or rejected. Generally speaking, the cosmological arguments of Book 1 of *De Revolutionibus* received hardly any attention at all before the cosmological debates that flowed from the observation of a supernova in 1572: Rheticus seems to have been the only natural philosopher to defend a Copernican cosmology before then. Furthermore, by 1600, despite a widespread acceptance of Copernicus's work in many other respects – complete astronomical tables based upon *De Revolutionibus*, which offered a simpler means of calculation than the cognate system of Ptolemy, came into general use from 1551, when the first set was published – there seem to have been few natural philosophers prepared to accept the physical reality of the heliocentric model.³ The attraction of the Copernican system from

2 An important corrective to this picture is William H. Donahue, 'The Solid Planetary Spheres in Post-Copernican Natural Philosophy', in Robert S. Westman, ed., *The Copernican Achievement* (Berkeley, 1975), 244–75.

3 Robert S. Westman, 'The Astronomer's Role in the Sixteenth Century: A Preliminary Study', *History of Science* 18 (1980), 105–47, finds only ten natural philosophers in the whole of Europe prepared to accept the physical reality of the heliocentric model in 1600: Digges and Harriot in England, Bruno and Galileo in Italy, Zúñiga (a problematic case – see below, n. 12) in Spain, Stevin in the Netherlands, and Rheticus, Maestlin, Rothmann, and Kepler in Germany. See also Robert S. Westman, 'The Melanchthon Circle, Rheticus, and the Wittenberg Interpretation of the Copernican Theory', *Isis* 66 (1975), 165–93; and Nicholas Jardine, 'The Significance of the Celestial Orbs', *Journal of the History of Astronomy* 13 (1982), 168–94. Although things changed very significantly in the course of the seventeenth century, it is worth noting that complete acceptance of the heliocentric theory took much longer. This reluctance to accept heliocentrism was not restricted to Catholic countries such as Spain, where resistance to Copernicanism continued at least up to the end of the eighteenth century (see David Goodman, 'Iberian Science: Navigation, Empire and Counter-Reformation', in David Goodman and Colin A. Russell, eds., *The Rise of Scientific Europe, 1500–1800* [London, 1991], 117–44, at 143). As regards Protestant countries, Blumenberg points out that it was not accepted as being beyond dispute in Germany

the point of view of calculation lay in the fact that it was much simpler than Ptolemy's account, eliminating five of his major epicycles; it also had the advantage of dispensing with a number of nondemonstrable assumptions, such as those needed by Ptolemy to fix the order of the planets. Its physical reality was an altogether different question, however. Although Copernicus, in Book 1, puts a realist gloss on his heliocentrism, his Aristotelian physical theory did not provide him with the resources to offer a physical defence of heliocentrism,⁴ and the implicit but undeniable fictionalism of the remaining five books goes a long way to supporting Osiander's explicitly fictionalist reading in the Foreword to *De Revolutionibus*. Given the inherent physical implausibility of the thesis of the Earth's motions (diurnal, annual, and, for Copernicus, that which maintains the direction of tilt of its axis of rotation), which seemed wholly undetectable – not to mention the fact that the behaviour of terrestrial bodies does not exhibit the properties naturally associated with rapidly rotating or revolving objects – and given the unprecedented vastness of the tract of space that Copernicus was required to posit between Saturn and the fixed stars to account for lack of stellar parallax, it is not surprising that many of the leading and most radical natural philosophers of the period rejected it outright: Cardano thought it nothing short of ridiculous, for example, and Telesio considered it profoundly mistaken.

There were a few natural philosophers who took the physical reality of heliocentrism literally, particularly in England, where we can find two published defences of Copernicanism as a physical theory in the sixteenth century: Thomas Digges's *A Perfit Description of the Cælestiall Orbes* (1576), in which he tells us that 'Copernicus mente not as some

until 1760 (*The Genesis of the Copernican World* [Cambridge, Mass., 1987], 357). In orthodox countries, moreover, 'modern' natural philosophy replaced Aristotelianism only in the 1870s in Kiev; and in Greece we find a teacher being condemned for teaching the heliocentric theory in 1804 (Colin Chant, 'Science in Orthodox Europe', in Goodman and Russell, eds., *Rise of Scientific Europe*, 333–60, at 355).

4 It may have provided him with a motivation, however, as it may have been his staunch adherence to the rigidity and impenetrability of celestial spheres that caused him to reject Ptolemy's equants, which required rotation around an off-centre axis, something physically impossible if the spheres are indeed rigid; this meant he would have had to look for an alternative mechanism, the epicycles described by thirteenth-century Arab astronomers being the best candidate, and substituting these for Ptolemy's equants points Copernicus in the direction of heliocentrism. This is the argument offered in Noel M. Swerdlow, 'The Derivation and First Draft of Copernicus' Planetary Theory: A Translation of the *Commentariolus* with Commentary', *Proceedings of the American Philosophical Society* 117 (1973), 423–512. See also his 'Pseudodoxia Copernicana; or, Enquiries into Very Many Received Tenets and Commonly Presumed Truths, Mostly Concerning Spheres', *Archives internationales d'histoire des sciences* 26 (1976), 108–58. Swerdlow's papers have provoked much controversy.

have fondly excused him to deliuer these grounds of the Earthes mobility onely as Mathematicall principles, fayned & not as Philosophicall truly asserted',⁵ and John Blagrave's *Astrologium Vranicum Generale* (1596), which is described, in part of its title, as 'Agreeable to the Hipothesis of Nicholaus Copernicus, the Starry Firmament is appointed perpetually fixed, and the earth and his Horizons continually mouing from West towards the East once about euery 24 houres',⁶ an hypothesis he takes in a realist sense; but most seemed to have ignored the question. For many it did not even seem to be a particularly contentious theory, because it was so easy to ignore its claims to physical significance, which were apparently easily refuted, and in any case those claims were seen as tangential to the real computational benefits of the model. Only when it was decisively dragged out of mathematics into the realm of natural philosophy did it begin to act as a catalyst for the upheaval we now refer to as the Scientific Revolution. Matter theory played a crucial role in this shift, and it is worth remembering that early critics of geocentrism, such as Bruno, defended an atomistic theory of matter and an explicitly Lucretian cosmology, with its radical doctrine of the infinity of space, where any notion of a centre was meaningless.

The physical interpretation of Copernicanism was defended on the basis of a theory of matter quite different from the Aristotelian conception that had been used to fill out the Ptolemaic theory. Moreover, the development of a new theory of matter had to some extent been allowed by the divide that had opened up between natural philosophy and metaphysics. Natural philosophy was now beginning to operate under a different set of constraints, and although to a large extent it had been the conflict between the Aristotelian conception of matter and Christian theology that was instrumental in precipitating the divide, once natural philosophy became subject to these different, and less constrictive, constraints, there was no longer any compelling reason why it had to be pursued via an Aristotelian theory of matter rather than an atomist one.⁷

5 Thomas Digges, *A Perfit Description of the Cælestiall Orbes . . .*, appendix to Leonard Digges's *A Prognostication euerlastinge . . . Lately corrected and augmented by Thomas Digges* (London, 1576), sig. M1r. His account accompanies an English version of the crucial chapters of Book 1 of *De Revolutionibus*.

6 One might add Robert Recorde's *The Castle of Knowledge* (London, 1556), which is sympathetic to Copernicanism without actually defending it explicitly. See Francis R. Johnson, *Astronomical Thought in Renaissance England: A Study of English Scientific Writings from 1500 to 1645* (Baltimore, 1937), 126–30.

7 Although there had been mediæval discussions of *minima naturalia*, these discussions were carried out within the context of Aristotelianism, and there was no development of the idea within the context of traditional atomism. By the seventeenth century, things had changed and Daniel Sennert, for example in his *De Chymicorum*

The sixteenth-century 'emancipation' of natural philosophy, as it might be termed, allows atomism freer rein than was possible earlier. Nevertheless, on the face of it, it might seem that the constraints are removed only to be replaced by others that effectively do the same work. After all, Bruno, almost certainly following Nicholas of Cusa, introduced a Neoplatonic spirit-world to animate his Lucretian universe, thereby avoiding some of the traditional associations of atomism with determinism and atheism.⁸ Yet in one respect this is very radical indeed, for it engages a very different conception of metaphysics, stretching back to Anselm of Canterbury and Ramón Llull, in which metaphysics is explicitly a science of God rather than a science of being, and in which God is integrated into nature in a way that orthodox theologians, for whom the transcendence of God was the keystone of their theology, completely rejected.⁹ Moreover, it should be noted that the apparently more radical form of corpuscularianism that we find in Mersenne, Descartes, and others, whereby matter is completely inert (much as Epicurus and Lucretius conceived it) was originally motivated less by natural-philosophical considerations than by a sense that the naturalistic accounts of Bruno, Telesio, Campanella, and others, which made nature an 'active realm', undermined the transcendence of God and clouded the crucial distinction between the supernatural and the natural, or between the Creator and his creation.¹⁰

Up to the second decade of the seventeenth century at least, there is a strong case to be made that matter theory was a far more contentious and dangerous area than Copernicanism.¹¹ However, when efforts to establish the physical reality of the heliocentric thesis inevitably moved it from mathematics into natural philosophy, what it was moved into was a natural philosophy that, partly as a result of being emancipated from metaphysical and theological issues, had become underpinned by theories of matter that diverged radically from Aristotle's. In addition, far from bridging the gap that the Aristotelian theory of matter had opened

cum Aristotelicis et Galenicis Consensu ac Dissensu (Wittenberg, 1619) and in *Hypomnemata Physica* (Frankfurt, 1636), tried to form a general corpuscularian account of matter by combining Aristotle's theory of *minima* with doctrines drawn from Paracelsus and Galen.

8 See the discussion in Andrew Pyle, *Atomism and Its Critics* (Bristol, 1995), 214–25.

9 See Charles Lohr, 'Metaphysics', in Schmitt et al., eds., *The Cambridge History of Renaissance Philosophy* (Cambridge, 1988), 537–638.

10 See my *Descartes, an Intellectual Biography*, 146–52.

11 I do not, however, believe this was true at the time of Galileo's trial, where Copernicanism, and not atomism, was clearly at issue, contrary to the claims in Pietro Redondi, *Galileo Heretic* (Princeton, 1989).

up between natural philosophy and a theologically constrained metaphysics, these new theories of matter actually widened this gap immeasurably. Natural philosophy had become a dangerous brew. The insertion of Copernicanism into it produced an explosion, and, notoriously, a rearguard attempt to bridge the gap was instituted, in the form of attempts to remove Copernicanism from natural philosophy – now effectively beyond redemption – and re-establish its purely mathematical and hypothetical character.¹² Copernicanism does not produce the radical changes that we associate with the development of science in the seventeenth century by itself, but only once is it fleshed out in terms of a natural philosophy, and it is matter theory that plays the key role in what form the natural philosophy takes.

As we have seen, Bacon, in common with most of his contemporaries, took Copernicanism to be a mathematical theory which was largely independent of natural philosophy; but his lack of interest in the mathematical precision of the theory takes him further, and his attempt to focus on the natural-philosophical essentials leads him to adopt a cosmology which is as striking in its natural-philosophical simplicity as it is in its negligence in accounting for observational detail in a quantitatively satisfying way. The cosmology he takes up is one in which the Earth lies at the centre of a system of spheres all of whose orbits are centred upon the Earth. In this homocentric system, all the planets have regular circular orbits in the same direction. It was realised at an early stage in the development of astronomy that such an account did not fit the observational data. At the most elementary level, for example, the nearer planets varied in brightness in a continuous and systematic way, indicating that they were approaching or receding from the Earth during at

12 It is true that some Aristotelians in Iberian countries attempted to respond to the challenge by reformulating Copernicanism in terms of an Aristotelian natural philosophy, that is, within the confines of an Aristotelian theory of matter, thereby establishing its legitimacy as a physical theory in an orthodox way; but I think the impossibility of this approach had become clear as early as the sixteenth century. Diego de Zúñiga, in his *Commentary on Job* (*In Job Commentaria* [Toledo, 1584]) had argued the theological credentials of Copernicanism, namely that Holy Writ, if correctly interpreted, did not deny the assertion of Solomon in the *Ecclesiastics* that 'the Earth is fixed forever'. What this means, he argued, is that the Earth is always the same, and not that it does not move at all. Thirteen years later, however, in his *Philosophia Prima*, Zúñiga offered a purely natural-philosophical examination of Copernicanism, concluding that Copernicus's system was physically impossible – as indeed it is, in the context of Aristotelian natural philosophy, despite the valient efforts of seventeenth-century Aristotelians to argue otherwise. On these questions see Víctor Navarro Brotóns, 'The Reception of Copernicus in Sixteenth-Century Spain: The Case of Diego de Zúñiga', *Isis* 86 (1995), 52–78; and Beatriz Helena Domingues, 'Spain and the Dawn of Modern Science', *Metascience* 7 (1998), 298–312.

least part of their motion.¹³ Ptolemy tried to resolve the complexities of the observational data, while reconciling these with a geocentric universe, by abandoning concentric spheres and introducing epicycles and movable eccentrics. This approach, though it allowed the data to be taken into account, had no obvious natural-philosophical rationale: It had an air of merely 'saving the appearances', accounting for the different lengths of the seasons, for example, by making the Sun's orbit eccentric, so that it now revolved not around the Earth but around a point at some mathematically convenient distance from the Earth. Largely in response to such considerations, the late-twelfth-/early-thirteenth-century astronomer Alpetragius revived the homocentric theory, rejecting the independent movement of planets from east to west that had characterised Ptolemy's account. He realised that the theory had to be modified – for example, to account for the fact that the poles of the ecliptic differed from the celestial poles, and for the fact of the variable velocities of the planets in longitude – and to do this he suggested that the poles of each planet describe small circles around their mean positions in each period of the planet, and he altered the accepted positions of the planets, putting Venus between Mars and the Sun. The theory proved inadequate to account for the observational data – it could offer no convincing account of retrograde arcs, for example – but despite its inadequacies, the theory had an obvious natural-philosophical rationale: The Earth was at the centre of the cosmos and the planets, stars, and the firmament revolved around it. This firmament consisted of nine concentric spheres placed around the Earth at the centre, all moving in the same direction, and carrying the Moon, the planets and the Sun, the fixed stars, with the outermost sphere, which was the single 'prime mover', completing its own motion from east to west in just under one sidereal day. Although the prime mover carries the other spheres around with it, there is a lag in the motion of each sphere, increased as one moves inwards from the prime mover, and there is also an increased deviation from a circular orbit as one moves inwards, with inner planets moving in what Bacon describes as spirals (but which are, more strictly speaking, helices wrapped around spheres) – a very distinctive feature of Alpetragius's account which Bacon follows.

Alpetragius's approach did have a natural-philosophical rationale, which was set out eloquently by Averroës, with whom he shared both a teacher (ibn-Tofail) and a hostility to the Ptolemaic system:

The astronomer must, therefore, construct an astronomical system such that the celestial motions are yielded by it and that nothing that is from the stand-

13 See D. Hargreave, 'Reconstructing the Planetary Motions of the Eudoxian System', *Scripta Mathematica* 28 (1970), 335–45.

point of physics impossible is implied. . . . Ptolemy was unable to see astronomy on its true foundations. . . . The epicycle and the eccentric are impossible. We must, therefore, apply ourselves to a new investigation concerning that genuine astronomy whose foundations are principles of physics. . . . Actually, in our time astronomy is nonexistent; what we have is something that fits calculation but does not agree with what is.¹⁴

Averroës had hoped to complete this study himself, but it was left to Alpetragius to carry it out.¹⁵ A number of Christian mediæval thinkers, such as Albertus Magnus and Aquinas, who either rejected concentric orbs or were noncommittal,¹⁶ considered it seriously at one time or another, if only subsequently to reject it. There seems to have been a widespread sense that there was something artificial about the Ptolemaic system, and Alpetragius came closest to providing a physically satisfying geocentric model. The homocentric model underwent a revival in the early sixteenth century in the works of the Paduan natural philosophers Fracastoro and Amico, who, following Averroës, regarded the Ptolemaic system as unnatural.¹⁷ The reasons why Bacon, who wrongly ascribes the theory to Telesio,¹⁸ should have revived an account whose inadequacies seem to have been recognised by everyone but him – Clavius, for example, had given it a complete drubbing from which it could not have recovered¹⁹ – surely turn on the fact that it makes more natural-philosophical sense of geocentrism than does the Ptolemaic model.

There is something to be said for such considerations, and Bacon cannot be faulted for raising them and preferring a model that appears to capture the physical point of the exercise in a better way than does Ptolemy's (or Tycho Brahe's, for that matter). After all, it was just such an approach that led Kepler to question Copernicus's version of the heliocentric theory, which had the motions of the planets centred on a

14 Averroës, *Metaphysics*, lib. 12, summæ secundæ cap. 4, comm. 45. Quoted in Pierre Duhem, *To Save the Phenomena: An Essay on the Idea of a Physical Theory from Plato to Galileo* (Chicago, 1969), 31.

15 See Duhem, *To Save the Phenomena*, 31–2.

16 Aquinas, for example, was noncommittal in *De trinitate* and rejected concentric orbs in his *Commentary on the Metaphysics*: See Edward Grant, *Planets, Stars and Orbs: The Medieval Cosmos, 1200–1687* (Cambridge, 1994), 281.

17 Girolamo Fracastoro, *Homocentrica: Sive de Stellis* (Venice, 1538); Giovanni Battista Amico, *De Motibus Corporum Cælestium iuxta Principia Peripatetica sine Eccentris et Epicyclis* (Venice, 1536). On the sixteenth-century revival of the homocentric thesis, see James M. Lattis, *Between Copernicus and Galileo: Christoph Clavius and the Collapse of Ptolemaic Cosmology* (Chicago, 1994), 87–94.

18 Rees points out that this indicates that his acquaintance with the account derives from Tommaso Campanella's *Philosophia, Sensibus Demonstrata* (Naples, 1591), where the two are discussed together. Rees's arguments are summarised in his Introduction to Bacon's natural-philosophical writings: *BW* vi.xxxviii–xxxix.

19 See Lattis, *Between Copernicus and Galileo*, 91–4.

mathematically determined entity called the 'mean sun', different from the Sun itself. This might make mathematical sense, but Kepler was worried about what physical sense it made: Surely real physical things like planets would have their orbits determined by something physical, namely the real physical Sun. The difference lies in the fact that Kepler's attempt to flesh out the physical rationale for heliocentrism works under rigorous constraints: The observations, now available – because of Tycho's work – at an unprecedented level of accuracy, have to be accounted for precisely. Alpetragius made some efforts in this direction in his attempt to take the geocentric model back to a physical picture of the cosmos that had a clear physical rationale, although he did not pursue the matter to the end, probably because it became clear that he was not going to be able to account for retrograde motions. Bacon, however, simply ignores this constraint, perhaps on the assumption that once the correct physical account had been produced, the observational and mathematical aspects would simply fall into place.

Bacon's advocacy of Alpetragian model also turns, though, on the fact that he has a matter theory, derived from Paracelsus and Telesio, which enables him to provide a grounding for such a model. Reconciling astronomical observations in a fine-tuned way holds little interest for Bacon. His concern with matter theory, on the other hand, is quite different: It is a concern with a discipline which he took to be at the cutting edge of natural philosophy – as indeed it was.

The sources of Bacon's matter theory

Although Bacon discusses the philosophers of classical antiquity – sometimes in some detail, as we have seen – he rarely discusses his more immediate sources. In the course of his various accounts of matter theory, however, we can identify a number of sources from the middle of the sixteenth century to the beginning of the seventeenth. Among these, Paracelsus and Telesio are key figures, although Campanella and Gilbert also play a very significant role.²⁰ Paracelsus offered what was effective-

20 Graham Rees has pioneered the study of Bacon's matter theory in a number of papers, including: 'Francis Bacon's Semi-Paracelsian Cosmology', *Ambix* 22 (1975), 81–101; 'Francis Bacon's Semi-Paracelsian Cosmology and the *Great Instauration*', *Ambix* 22 (1975), 161–73; 'Matter Theory: A Unifying Factor in Bacon's Natural Philosophy?', *Ambix* 24 (1977), 110–25; 'Francis Bacon on Verticity and the Bowels of the Earth', *Ambix* 26 (1979), 202–11; 'Atomism and "Subtlety" in Francis Bacon's Philosophy', *Annals of Science* 37 (1980), 549–71; 'Bacon's Philosophy: Some New Sources with Special Reference to the *Abecedarium Novum Naturæ*', in Marta Fattori, ed., *Francis Bacon: terminologia e fortuna nel XVII secolo* (Rome, 1984); 'Francis Bacon and Spiritus Vitalis', in M. Fattori and M. Bianchi, eds., *Spiritus: IV° Colloquio Internazionale del Lessico Intellettuale Europeo* (Rome, 1984), 265–81. A number of his conclusions are set out in Part 2 of his Introduction to *BW* vi.

ly the most important alternative to Aristotelian matter theory, and it is from his work that Italian matter theorists took their bearings. Certainly no understanding of Bacon's matter theory is possible without some grasp of what Paracelsus's revolution comprised.

Paracelsus was, to say the least, a controversial figure.²¹ He was the son of a physician, from whom he learned medicine and alchemy, and, possibly after studying at the University of Basel, he went, in 1514 at the age of twenty, to work in the Fugger mines in the Tyrol, picking up a good deal of knowledge about metallurgy, and writing the first treatise on occupational diseases as a result of his experiences. He subsequently acted as an army surgeon, and then as a physician. His matter theory is very much in the alchemical tradition, but he regarded the traditional alchemical goal of transmuting base into precious metals as secondary, his aim being to prepare therapeutic substances, for which, contrary to the usual procedure, he used inorganic material.

Paracelsus's aim, then, is resolutely practical: the discovery of remedies for human maladies, from disease to the aging process. Whereas the traditional notion of disease as humoral imbalance or overindulgence made each disease dependent upon the constitution of the sufferer,²²

21 On Paracelsus see Allen G. Debus, *The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries*, 2 vols. (New York, 1977); idem, *The English Paracelsians* (New York, 1966); Walter Pagel, *Paracelsus: An Introduction to Philosophical Medicine in the Era of the Renaissance* (Basel, 1958); and Andrew Weeks, *Paracelsus: Speculative Theory and the Crisis of the Early Reformation* (Albany, 1997); see also the very useful chapter on Paracelsus in E. J. Holmyard, *Alchemy* (Harmondsworth, 1957) and the scattered material in vols. 6 and 7 of Lynn Thorndike, *A History of Magic and Experimental Science*, 8 vols. (New York, 1923–58). In his *The Anatomy of Melancholy* (2 vols. [1st ed., 1621; London, 1826]), Robert Burton writes:

Paracelsus and his Chymistical followers, as so many *Promethei*, will fetch fire from heaven, will cure all manner of diseases with minerals, accounting them the only physick on the other side. Paracelsus calls Galen, Hippocrates and all their adherents, infants, idiots, sophisters, &c. *Apagesis istos qui Vulcanias istas metamorphoses sugillant, inscitiae soboles, supinae pertinaciae alumnos* [Away, he says, with those that jeer at Vulcanian metamorphoses, ignorant sprouts, backward and stubborn nurselings] &c. not worthy of the name of physicians, for want of these remedies; and brags that by them he can make a man live 160 yeers, or to the worlds end. With their *alexipharmacums, panaceas, mummiæ, unguentum armarium*, and such magnetical cures, *lampas vitæ et mortis, balneum Dianæ, balsamum, electrum, magico-physicum, amuleta Martialia*, &c. what will not he and his followers effect? He brags moreover that he was *primus medicorum*, and did more famous cures then all the physicians in Europe besides: a drop of his preparations should go farther than a dram, or ounce of theirs, those loathsome and fulsome filthy potions, heteroclitical pills (so he calls them), horse medicines, *ad quorum aspectum Cyclops Polyhemus exhorresceret* [at the sight of which the Cyclops Polyhemus would shudder]. (ii.99–100, Part 2, sect. 2, mem. 1, subs. 4)

22 This made it particularly ill-equipped to deal with plagues and epidemics, and, perhaps partly as a result of this, these were often seen in religious rather than medical terms.

Paracelsus conceived of diseases as separately classifiable entities, having definite identifiable causes and anatomical effects. He saw the causes in the mineral realm and in the air, and the remedies also, the aim being to transform various raw materials from the mineral realm into therapeutic substances. To do this, one needs to understand the nature of human maladies, and what the raw materials in nature are, and how they might be transformed. On the first question, Paracelsus offers an account of sickness and health as being controlled by astral influences. Since the Earth and the heavens form a single whole, and since the human microcosm mirrors the macrocosm of nature, the same kinds of processes that regulate nature generally regulate human physiology. Sickness can be driven out by restoring the harmony between the celestial bodies and the human body, for it is such lack of harmony that is the cause of sickness in the first place. A medicine effects healing by reaching out to the stars, and since the medicine must of necessity be material, it must operate via a form of matter which can genuinely establish such contact: something gaseous or volatile. In his pamphlet *Panagranum* ('Against the Grain') of 1529, he takes the three pillars of medicine to be astronomy, philosophy, and alchemy.²³ The first comprises two elements, air and fire, and the second comprises the other two elements, namely earth and water. Alchemy deals with something deeper, what it is that underlies the elements, something that points us to the vital principle (*astrum*) of the thing and provides the secret remedy (*arcantum*) which holds the key to illness:

It is not the physician that controls and directs, but heaven, by the stars; and therefore the medicine must be brought into an airy form in such a manner that it may be directed by the stars. For what stone is lifted up by the stars? None save the volatile. Hence many have looked for the *quintum esse* in alchemy which is nothing else but that thus the four elements are taken away from the arcantum, and what remains afterwards is the arcantum. The arcantum furthermore is a chaos [gas], and it is possible to carry it to the stars like a feather before the wind. The four elements are taken away from the arcantum, and then it should be known what *astrum* is in this particular arcantum, and what is the *astrum* of this particular disease, and what *astrum* is in the medicine against the disease. This is where the directing comes in. If you are given a medicine, the stomach has to prepare it, and it is the alchemist. If it is possible for the stomach so to manage it that the *astra* accept each other, the medicine is directed; if not it remains in the stomach and goes out through the stool. For what is more noble in a doctor than a knowledge of the concordance of both *astra*? – for there lies the basis of all diseases. Now alchemy is the outer stomach which prepares for the stars its own. The purpose of alchemy is not, as it is said, to make gold and silver, but in this instance to make arcana and direct them against diseases; as this is the outcome, so it is also

23 See the discussion in Weeks, *Paracelsus: Speculative Theory*, 146–57.

the basis. For all these things conform to the instruction and test of nature. Hence nature and man, in health and sickness, need to be joined together, and to be brought into mutual agreement. This is the way to heal and restore to health. All this can be achieved by alchemy, without which these things cannot be done.²⁴

On the question of what raw materials there are in nature and how they might be transformed into therapeutic substances, Paracelsus draws on two different traditions. These are the Aristotelian theory of the four elements and the sulphur–mercury theory of metals. The first was interpreted differently by different writers, but basically the received view as presented in Aristotelian textbooks on natural philosophy in the sixteenth and early seventeenth centuries was that the imposition of form onto a propertyless substratum, ‘prime matter’, yielded four elements: earth, air, fire, and water. These were combinations of the four qualities – hot, cold, dry, and wet – and the character of the elements was thought to depend on the forms of the qualities from which they were composed and the nature of their union with matter. So, for example, water is wetter than air because its matter is denser, and the union of form and matter closer.²⁵ The second ingredient was the alchemical sulphur–mercury theory of metals, which can be traced back to early Arab commentators. This theory classified the known metals – gold, silver, iron, copper, tin, lead, and quicksilver (mercury) – in terms of an interaction between two basic principles, designated as mercury and sulphur.²⁶ Noting that all metals are lustrous and dense, yet showed the qualities of quicksilver when molten, the advocates of this theory argued that all the metals exhibited a ‘mercurial’ principle, similar to ordinary quicksilver but not identical with it. It was the combination of this principle with a opposing ‘sulphur’ principle that give the different metals their different characteristics. The theory should not be considered as being opposed to the Aristotelian account of the elements, but rather as taking the principles underlying that theory in a new direction. The eighth-century Arab alchemist Jabir, for example, argued that lead is cold and dry externally and hot and moist internally, whereas gold is hot and moist externally and cold and dry internally. The metals were formed in the Earth, he infers, by the union of sulphur, which provided the hot and dry natures, and mercury, which provided the cold and moist natures.

Paracelsus transforms this account. He adds a third principle to mercury and sulphur, namely salt, and takes these three principles (remembering all the while that these are abstract principles and not the sub-

24 Quoted in Holmyard, *Alchemy*, 171–2.

25 See the discussion in Hugh Kargon, *Atomism in England from Hariot to Newton* (Oxford, 1966), 2–3. He uses the textbooks of Scipion Dupleix and Magirus.

26 See Holmyard, *Alchemy*, 75.

stances that go by these names) as being in effect more fundamental than the elements, which become devoid of qualities in their own right on his account, and are governed by the three principles. Sulphur gives bodies oiliness, inflammability, viscosity, and structure; mercury gives them wateriness, spirit, vapour, and vivifying powers; finally, salt gives them rigidity, solidity, dryness, and earthiness. For many Paracelsians, these principles had particular cosmological significance, and one of his followers, Joseph Duchesne, offered a cosmogony which is similar to the account that Bacon will propose.²⁷ As Rees points out,²⁸ Duchesne's universe begins as a mass of chaotic water, which is divided by God into the sublunar and the celestial realms, the latter containing pure 'spiritual' matter. By a process of distillation, God then separates out the subtle, airy, mercurial liquor from the gross, oily, sulphurous liquor, and then, from the latter, he separates out a dry, saline residue. In this way, Duchesne associates fire (terrestrial and celestial) with sulphur, water and air with mercury, and earth with salt. The sublunary elements also figure, however, in the celestial realm, in a very refined form, and in the highest sublunary realm, air. Sulphur is active in planetary and stellar fires, and in comets (considered to be sublunary). Mercury is active in celestial influxes and winds. Salt is active in the crystalline spheres, and in thunderbolts, dew, and frost. As Rees points out,

Duchesne's system represented standard features of a resurgent philosophy which interpreted the universe through chemical theories assimilated to a naturalistic, magical, quasi-Hermetic metaphysic. The metaphysical vision, with its omnipresent concordances of macrocosm and microcosm, and faith in the efficacy of Holy Writ in natural philosophy, seems remote from the intellectual style generally associated with Bacon's name. Nevertheless the chemical theories built into that vision gave him the materials for a system which, though independent of the Paracelsian metaphysic, everywhere declared its origins.²⁹

Bacon desacralises Paracelsus's universe in important respects, ridding it of many of its Neoplatonically inspired hierarchies. This he achieves by grafting on to the Paracelsian universe a somewhat more economical conception of matter derived from Telesio, whom he praises as 'a lover of truth, a man useful to the sciences, a corrector of certain doctrines, and the first of the moderns'.³⁰

²⁷ Joseph Duchesne, *Liber de Priscorum Philosophorum Veræ Medicinæ Materia Præparationis Modo* (Paris, 1603), and *Ad Veritatem Hermeticæ Medicinæ ex Hippocratis Veterumque Decretis* (Paris, 1604). On Duchesne see Allen G. Debus, *The French Paracelsians* (Cambridge, 1991), chaps. 2 and 3.

²⁸ BW vi.xlv. I follow Rees's account here.

²⁹ Ibid., vi.xlvi.

³⁰ *De Princ.*: BW vi.258/259.

Telesio strips the four traditional qualities down to two, heat and cold, and these are qualities of an inert receptacle, matter, which is clearly a version of Aristotle's 'prime matter'. The interplay between heat and cold, which are opposing principles, produces the different natures of things, whether at the level of particular things or at the cosmological level, where the position of the Sun and the Earth is accounted for in terms of their respective heat and coldness. Telesio's stated aim is to examine physical processes in terms of their own principles – *iuxta propria principia* – rather than in terms of some abstract schema imposed on them from outside, as Aristotle had tried to do. Telesio begins *De Rerum Natura iuxta Propria Principia*³¹ with a criticism of Aristotelians, telling us that he is not as quick-witted, confident, or ambitious as they are, and that he follows only observations and sense experience. The idea of an empirical procedure that will 'level men's wits' will, of course, become a distinctively Baconian theme; but so will some of the more substantive content of Telesio's natural philosophy.

Telesio uses the contrast, or rather struggle, between hot and cold to explain all physical phenomena at the most fundamental level. Because of its great heat, for example, the Sun was propelled into perpetual motion, whereas the Earth, which is characterised by cold, is immobile because of its great weight. The whole cosmic balance and harmony depends on the struggle and equilibrium between these two. Nevertheless, the principles of heat and cold are far too slender a base on which to build a natural philosophy: Cosmic equilibrium depends, after all, upon interaction among the parts of the cosmos, but the basic or prime matter that bears the qualities of hot and cold is inert. Telesio has effectively to supplement his two basic principles to deal with this problem, and he introduces a mode of interaction among things, *spiritus*, which goes beyond these principles. Telesio construes nature not as dead and inert, but as active and endowed with powers, and he takes this as an empirical, observational fact about nature. It is accounted for through the notion of *spiritus*, something which is incorporeal and present everywhere in the cosmos – effectively making everything sentient, to a greater or lesser degree; and since everything except God is material, this means that everything is both material and sentient.³² Bacon will develop this no-

31 Bernardino Telesio, *De Rerum Natura iuxta Propria Principia Libri IX* (1st ed., 1565; Naples, 1586); there is a facsimile reprint of this edition (Hildesheim, 1971). On Telesio's natural philosophy, see Martin Mulsow, *Frühneuzeitliche Selbsterhaltung: Telesio und die Naturphilosophie der Renaissance* (Tübingen, 1998).

32 Telesio does allow that there may be some higher forms of cognitive activity that may be nonmaterial. See D. P. Walker, 'Francis Bacon and *Spiritus*', in D. P. Walker, *Music, Spirit and Language in the Renaissance*, ed. Penelope Gouk (London, 1985), 121–30.

tion of *spiritus* in detail beginning with the later drafts of *De Vijs Mortis*, which date from the late 1610s, although the notion is relevant to the cosmological writings from this period, where he operates with a notion of matter which has properties that go beyond anything that would be possible were it simply a question of the imposition of form on an inert material substratum.

Atomism and motion

In a fragment dating from around 1604, *Cogitationes de Natura Rerum*,³³ Bacon raises a number of substantive natural-philosophical issues. He begins by spelling out what he takes to be the strengths of Democritean atomism.³⁴ The internal constitution of things can, he notes, be shown to be both of a scale much smaller than visible particles, and very diverse, by considering the case of saffron, which behaves very differently from the finest powders. A very small amount of saffron will change the colour of a very large amount of water, something no powder will do, and this indicates that its parts are much smaller than those of powders, and that they must be smaller than the dust particles visible in light rays, which many had taken to be atoms. Odours are even more striking in this respect, in that they are localised, and hence made up of material particles of definite size and extension, but these particles are of a size well below the range of visibility. While Bacon is agnostic on the existence of a large-scale vacuum, he holds that there must be interatomic vacua, the atoms themselves being completely solid, if the phenom-

33 *Works* iii.15–35/v.419–39. Subsequent citations in this section to *Cogitationes de Natura Rerum* will be given parenthetically in the text solely by *Works* volume and page.

34 The principal source seems to be Lucretius, who does not offer ‘pure’ Democritus, although Bacon was also certainly familiar with Democritus’ doctrines from Aristotle’s criticisms, and he would certainly have used the account in Diogenes Laërtius, *Lives of Eminent Philosophers*. There is a later short fragment, *Abecedarium Naturæ*, ‘the alphabet of nature’, which provides an untypically metaphysical excursus entitled ‘conditions of beings’, in which the various kinds of being are set out in terms of limitations to being (*Abec. Nat.: Works* ii.85–8/v.208–11). So, for example, being itself is either possible or impossible, if it exists it is either plentiful or rare, durable or transitory, eternal or momentary, natural or unnatural. The alphabet comes in here because Bacon sees there being a hierarchy: ‘Possible or impossible’ is more primitive than ‘plentiful or rare’, for example, and so merits an earlier place in the alphabet. The rationale given for this peculiar exercise is tied up with Democritus’ claim that there is an infinite quantity of matter but very few genuinely distinct species, so we should be able to build up the basic species from first principles. So far as I can tell, this notion does not reappear, and it is an organisational principle of a kind and generality that Bacon does not employ elsewhere.

ena of expansion, compression, dilution, and so on are to be explained (iii.15–17/v.419–21). As to the variety in atoms themselves, he contrasts a Democritean view, by which atoms have different properties, and a Pythagorean view, whereby all atoms have identical properties, and are ultimately associated with numbers.³⁵ Taking the important question to be the transformation of matter from one kind into another, he suggests that atoms themselves are indeed equal, but that congeries of atoms have properties different from one another, the implication being that it is these congeries that bear the explanatory weight. The point is reinforced through a criticism of attempts to explain various physical and chemical processes, such as the boiling of water, in terms of finer atoms separating off from grosser ones: The attempted explanations either ignore the fact that all of the water can boil away, or mistakenly take minute residues left after boiling to be gross parts of the water (iii.15–17/v.422–3).

In the third chapter of the *Cogitationes*, Bacon makes a crucial distinction between understanding how things are made up and of what they consist, an exercise he associates with disputatious Scholastics, and by what force and in what manner they come together, and how they are transformed. It is the latter that we must seek to understand, for this is what leads to the augmentation and amplification of human powers. To restrict ourselves to the former is to approach nature as if we were examining the anatomy of a corpse. We must not concern ourselves with the classification of motions as being natural or violent, as Aristotle did, but investigate instead those ‘appetites and inclinations and things by which all of the many effects and mutations that are evident in the works of nature and art are made up and brought about’ (iii.20/v.425). In this way, we will discover and distinguish the different kinds of motion, and then we will be able to hasten or arrest these, and by doing this change and transform matter.

35 We do not normally associate Pythagoras with atomism, but he was taken as an atomist by a number of seventeenth-century writers, and his version of atomism was to be defended at length in Ralph Cudworth, *The True Intellectual System of the Universe*, 2 vols. (London, 1678). Diogenes Laërtius (*Lives of Eminent Philosophers*, ed. and trans. R. D. Hicks, 2 vols. [Cambridge, Mass., 1925], Book VIII, 25) sets out what seems to me to be the relevant doctrine as follows:

The principle of all things is the monad or unit; arising from this monad the undefined dyad or two serves as material substratum to the monad, which is cause; from the monad and the undefined dyad spring numbers; from numbers, points; from points, lines; from lines, plane figures; from plane figures, solid figures; from solid figures, sensible bodies, the elements of which are four, fire, water, earth, and air; these elements interchange and turn into one another completely. . . .

Ellis notes that Stobæus, *Eclog.* I.16, speaks of atoms and the void as first principles in Pythagoras.

This leads Bacon, in the remaining chapters, to a fuller consideration of the nature of motion, as a foundation for his natural philosophy. His basic complaint against the prevailing account of motion, essentially that of Aristotle, is that motions are distinguished in terms of effects, whereas we need to understand motions in terms of their causes. Aristotle had classified change generally in terms of its *termini*. If the starting point of the change and the end point are contraries, as when a substance comes into or goes out of existence (e.g., birth and death), then we have one kind of change. When the substance itself does not change but only its properties, as in change of place, then we have a different kind of change. Although Aristotle believes that change of place, or local motion, is an important and pervasive form of change, ultimately it is just one of a large number of kinds of change, having no priority over other forms. Bacon, following the atomist view, is committed to the idea that local motion underlies all other kinds of change, that, ultimately, local motion is the only form of change, although this will often be obscured at the macroscopic level: hence the importance of the search for underlying causes. These underlying causes must, Bacon asserts, be far simpler than the varieties of motion classified by Aristotle and his followers: ‘if we are to study nature with skill, we must discover the path to simpler phenomena’ (iii.21/v.426). These simple motions he compares to the letters of the alphabet, natural philosophers to date having dealt with nature like early people dealt with words and sounds, failing to see how they were made up of their constituent parts. Summing up the rationale behind the study of simple motions, he writes that

the principles, sources, causes, and forms of motions, that is, the appetites and passions of every kind of matter, are the proper objects of philosophy, and after this the collisions or impacts of motions, the restraints and resistances, the free passages and obstructions, the interchanges and mixtures, circuits and sequences, in short, the universal process of motions. (iii.21–2/v.426)

Note that the language here is not that we associate with the mechanical philosophies of the first half of the seventeenth century, those of Beeckman, Descartes, Gassendi, and Mersenne, for example. The idea of the ‘appetites and passions of matter’ conjures up an image not of inert matter, central to the mechanist project, but of nature as an active realm: the kind of thing we find in Renaissance naturalists such as Paracelsus and Telesio, who envisage matter very much as part of an active realm, and who are Bacon’s sources in this respect.

In the Aristotelian classification of change that Bacon rejects, Aristotle draws attention to those kinds of change – generation and corruption – in which something material comes into existence and goes out of existence. It would be difficult to explain such processes in terms of the local

motion of microscopic atoms, and Bacon rejects the idea of changes in the total quantity of matter: God, of course, can create and destroy matter, but Bacon believes it to be well established (*satis constat*) that, as a matter of fact, the total amount of matter remains the same (iii.22/v.426–7). Differences between different kinds of matter he treats as being differences between the concentration of atoms, and he allows, for example, that air and water might be interconvertible. In connection with the conservation of the total quantity of matter, he sets out three precepts. The first is that when a sensible body disappears (when water evaporates, for example), one must investigate where the matter it contained has been transferred to; second, in investigating the constituents of a substance by acting upon it in some way, one should find new ways of breaking the substance up into its constituents, and in particular, one should go beyond the well-understood processes of boiling down and separating out (as in the separating out of cream from milk); third, in understanding the changes that can occur to a substance, one must not suppose all these to be due to a separation of its constituents.

At this point Bacon introduces a distinctively Democritean and anti-Aristotelian theme, namely, that atoms are naturally in a state of constant motion. Bodies at rest may be so because they are held at rest by various forces: We should not assume that they are in some natural state (iii.25/v.429). He draws a lesson here for the difference between solids and liquids, rejecting the notion that it lies in the parts of the liquid striving to flow downwards and the parts of the solid being naturally at rest, for there is a striving downwards in both cases. In the latter case, however, this is countered by a stronger force, structural cohesion, or ‘avoidance of separation’, something which is occasionally manifest even in liquids, in the formation of bubbles, for example. In what, he asks, does this ‘avoidance of separation’ consist? It cannot be that the parts of solids are denser and more compact, for solids like snow and wax are rarer than quicksilver or molten lead; nor can it be that liquids have a *spiritus* which is the principle of fluidity, something absent in solids, for snow, a solid, is a mixture of air and water, which are fluids (iii.27/v.431).

In his Chapter 7, Bacon maintains that bodily or corporeal states (*passiones corporum*) are the same in sentient and nonsentient things, the difference lying in the fact that sentient things also possess a *spiritus* so that bodily states are accompanied by sensations of pleasure or pain.³⁶ This

36 In the somewhat obscure final two sentences of chap. 7, Bacon takes it to be a consequence of this that the right fundamental distinction of states of matter would correspond to the number of senses, if we added only the requisite organs and *spiritus*. However, it is unclear whether he is referring to the five senses here, or whether he believes that there may be other senses in animals, for he talks of ‘finding out whether it is possible for animals to have senses other than those we observe’ (*Works* iii.28/v.432–3).

raises the delicate question of the relation between corporeal states and *spiritus*, suggesting that actual cognition is something material, but that in the case of a sentient being (*corpore sensibili*) some affective state accompanies, or may accompany, the cognitive one.

Bacon's Chapter 8 deals with the category of 'violent motion', and his discussion of this topic is important because it is indicative of his general approach to natural philosophy. Aristotle had distinguished between natural objects and processes on the one hand, and artefacts and unnatural or constrained or violent processes on the other. Natural philosophy, for Aristotle, was concerned to explain the properties of things in terms of their essences. What lies at the basis of his schema is the distinction between those things that have an intrinsic principle of change, and those that have an extrinsic principle of change. 'Natural motion' comes in the first category, 'violent' motion in the second. Bacon's point is that it is 'violent' motions, not natural ones, which are the ones of interest: They are 'the life and soul of artillery, engines, and the whole enterprise of mechanics' (iii.29/v.433). He takes the example of projectile motion to show the inadequacies in the prevailing accounts of 'violent' motion. The problem of projectile motion in traditional natural philosophy was that of understanding what keeps a body in motion once it has left whatever it was that projected it. If I throw a stone into the air, for example, while the stone and my hand are in contact, the body receives its motion from my hand, but once it has left my hand it keeps moving upwards. Since in traditional natural philosophy, a body will only move in any direction other than downwards if there is a force propelling it (an assumption that Bacon evidently accepts), we need to ask what keeps the stone in motion once it has been separated from its original 'mover'. Aristotle's own explanation, which was that the motion of surrounding medium was responsible for the continued motion of the body, although still held by a few,³⁷ was widely regarded as implausible in the sixteenth century, and had been replaced by one or another version of *impetus* theory. Although *impetus* theory had originally been devised in the context of an attack on Aristotelian natural philosophy by the Platonist natural philosopher Philoponus in the sixth century, it could be, and was, incorporated into Aristotelian natural philosophy in the sixteenth century. On the sixteenth-century version of *impetus* theory, due to Jean Buridan, the motive force that caused the body to move upwards in the first place, a force which was of necessity external to the body, was transferred into the body, and was gradually exhausted due to the resistance of the air and the gravity of the body.

37 The last defence of this doctrine that I know of is that set out in chap. 12 of the first treatise of Sir Kenelm Digby, *Two Treatises . . .* (London, 1644), 100–5.

What Bacon's 'solution' to the problem of projectile motion amounts to is really just a Democritean gloss on *impetus* theory. Whereas *impetus* theory tries to provide a dynamical account of projectile motion, Bacon sees the issues in terms of the theory of matter.³⁸ What we have here is a key divergence of paths in seventeenth-century physical theory between the mechanical path and the theory of matter path. This is not to deny that there are deep connections between mechanics and the theory of matter. Some natural philosophers will employ both simultaneously: Descartes, for example, employs both in his account in *Le Monde* of why the planets travel in stable orbits around the Sun. Others will oscillate between the one and the other, as Newton does in shifting between the theory of matter developed in his 'alchemical' work and the completely mechanical approach of his *Principia*. However, as often as not, mechanics, modelled on either kinematics or statics and following a resolutely mathematical path, on the one hand, and matter theory, generally speaking (in the seventeenth century) qualitative and reductive, on the other, do represent different approaches to the fundamental problems of force and motion. Matter theory provided the model for those who saw the solution in a revival of traditional atomism – Telesio in Italy, Gassendi in France – and it had a particularly strong tradition in England, starting with Gilbert and Bacon, and reaching its apogee in Boyle, who transformed traditional atomism and began to move away from the purely qualitative approach it had fostered up until then.

Bacon's approach to the question of the continued motion of projectiles proceeds resolutely via an atomist theory of matter. He tells us that once the projectile has left the body that initiates its motion, the 'principal' motion is in the projectile itself, although this motion is too fine to be perceived and hence has been neglected. It takes the form of a pressure which is communicated from the part of the body to which the motion is initially conveyed and travels to the other end of the body, that is, in the direction of its motion, and this is indeed presumably what determines the direction of its motion. Two sets of considerations are brought to bear on this question. First, a flexible body which is bent and

38 His is a theory of matter at odds with Aristotle's, however. In the fourth of the projected six parts of the 'Great Instauration', appended to *Historia Ventorum*, Bacon notes that in antiquity the nature of heavy and light had been seen as the key to motion: Heavy things move downwards, light things upwards, since all bodies move to their natural places. He rejects this account, maintaining that bodies are affected only by other bodies, and 'there is no local motion which is not excited either by the parts of the body moved, or by the adjacent bodies, or by those contiguous or proximate to it, or at least by those which lie within its sphere of activity', and he gives qualified praise to Gilbert's attempt to understand magnetism in this latter respect (*Aditus: Works* ii.80/v.202).

then released flies off: Since the ends of the body are held by the fingers, the motion cannot derive from them but must derive from the centre of the body, where the pressure is greatest. This shows that the force or pressure is actually in the body, not in the medium surrounding it. Second, pressure is not localised in one part of a body but spread throughout it, as is evident when we strike a piece of glass with a hammer: It is not just the part we strike that shatters but the whole glass, showing that all the parts are connected.

There can be no doubt that Bacon's assessment of this explanation of 'violent and mechanical motion' as 'the fountain of practical operation' (iii.31/v.435) is optimistic in the extreme. Those genuinely concerned with practical operations, such as gunners who wanted to know what the angle of elevation of a cannon should be if projectiles fired from it were to reach the greatest distance, knew full well that projectiles did not simply travel in straight lines, for example, and Italian mathematicians and natural philosophers had been not only exploring the question of projectile trajectories in a sophisticated way, but publishing their results at least since Tartaglia's *Nova Scientia* of 1537.³⁹ Bacon's account, by contrast, is restricted to rectilinear motion, and it is difficult to see how it could plausibly be modified to account for motion in a parabola, for example. Indeed, it is difficult to see how an account of projectile motion which worked purely in terms of a theory of matter could possibly be satisfactory.

Still, if Bacon's account can hardly lay claim to being practical in this sense, we must nevertheless not lose sight of just what he is trying to achieve in providing an account of this kind. If we accept, as Bacon and many of his contemporaries did, that a theory of matter is the key to understanding force and motion, then we can concentrate on what Bacon sees as the central contrast, that between an atomistic account of matter and the Aristotelian account, the test case being the continuance of the 'violent' motion of bodies which are no longer in contact with the external force that initiated the motion. Aristotle's account has two drawbacks. First, it directs its prime attention to what it construes as the case of natural motions and natural states, whereas these are not the cases of practical interest. Second, when it turns to cases of 'violent' motion, such as the motion of a projectile, it provides an account which is quite unsatisfactory. Aristotle's own account can be improved upon, and the introduction of *impetus* theory did that; but the thrust of Bacon's argument seems to be that as long as one's basic natural philosophy is directed away from practical cases and towards ones of no practical value, we

39 Many of the relevant texts are collected and translated in Stillman Drake and I. E. Drabkin, *Mechanics in Sixteenth-Century Italy: Selections from Tartaglia, Benedetti, Guido Ubaldo, and Galileo* (Madison, 1969).

cannot expect the practical cases to be of anything more than marginal significance. His own atomistic account, on the other hand, does not work with such a strict separation between 'natural' and 'violent' motions, and allows one to account for all motions in terms of how powers can be stored mechanically in objects in the form of pressures, and this applies to celestial and sublunary bodies alike (iii.32–5/v.437–9), whereas Aristotle's account makes a sharp distinction between these two. To determine how a body will behave when a force has been exercised upon it, we need to know how its microscopic constituent parts have been modified by the force, where this modification takes the form of some alteration of the arrangement of the parts – squeezing, separation, and so on. The model of dynamic interaction is not impact, as it is in mechanical models, but elasticity.

Democritus and Cupid

Some time around 1612, Bacon set about revising parts of *De Sapientia Veterum*, and the result is an unfinished manuscript, *De Principiis atque Originibus*, the full title of which indicates the hermeneutic complexity of the piece: 'On Principles and Origins, according to the fables of Cupid and Cœlum, or the philosophy of Parmenides and Telesio and especially that of Democritus as it is treated of in the fable of Cupid.'

The myths of Cœlum and Cupid were discussed in *De Sapientia*,⁴⁰ but *De Principiis* offers a different kind of discussion, with a much more detailed focus on the natural-philosophical issues. The topic of the myths, on Bacon's reading, is 'the principles of things and the origins of the world',⁴¹ but the interpretations offered in *De Principiis* differ in some respects from the earlier ones, drawing a different lesson: Methodological questions about how we discover these principles, which are absent from *De Sapientia*, are well to the fore in *De Principiis*, and motion, which had played the fundamental role in *De Sapientia*, is now subordinated to natures of 'Forms', as matter theory takes over the pre-eminent explanatory role.

The myths are explicitly identified as prototypical versions of Democritean atomism, and Bacon interprets the (pagan) imposition of structure on the original chaos as the (Christianised) imposition of structure on 'primary matter'. This primary matter has no natural cause, and there is 'nothing prior to it in the order of nature' (vi.198/199). Its cause is God, and cannot be inquired into further,

40 They are the twelfth and seventeenth myths, respectively (*De Sap. Vet.: Works* vi.649–50/723–5 and 654–7/729–31).

41 *De Princ.: BW* vi.196/197. Subsequent citations in this section to *De Principiis* will be given parenthetically in the text solely by BW volume and page.

for there is a true and certain limit of causes in nature, and when we come to the ultimate force and positive law of nature, it is just as much a mark of an ignorant man and superficial philosopher to ask after or make up its cause as not to ask after the cause in things which are subordinate. . . . For nothing has corrupted philosophy as much as this inquiry about Cupid's parents, i.e. philosophers have not accepted the principles of things as they are found in nature and embraced them as a positive doctrine and as if they were articles of faith, but they have rather deduced them from the laws of discourse, the piddling conclusions of dialectic and mathematics, from common notions, and from such like excursions of the mind beyond the bounds of nature. (vi.198/199)

In other words, the basic principles of things are to be found in nature, and we cannot hope to – and should not seek to – reconstruct more fundamental principles which would supposedly underlie those in nature. It is not completely clear just what Bacon has in mind here, but it is likely that the point is that the properties of matter are not to be explained in terms of something supposedly more fundamental, such as types of motion, or the Aristotelian doctrine of potentialities and actualities; rather, we must take the nature of matter as given, and explain any such properties in terms of it. In other words, matter theory is the fundamental discipline: not mathematics, or mechanics, or Aristotelian metaphysics.

The proper means for the discovery of the fundamental principles of nature is something that Bacon had not investigated in *De Sapientia*, but he now tries to draw a method of discovery out of the myth. The key lies in the fact that Cupid is hatched from an egg by Night, for this 'is a happy allusion to the demonstrations which bring this *Cupid* to light' (vi.200/201). Only God can proceed via 'affirmatives': We must proceed via 'exclusions and negations', that is, by eliminative induction; and our starting point is '*Cupid* himself, that is primary matter' (vi.204/205), which Democritus, of all the ancient philosophers, understood best. This 'primary matter' is not to be confused with Aristotle's 'prime matter', which Aristotle conceives of as purely potentiality. Bacon writes of it as being something 'positive', and tells us that it was originally conceived as having 'form and properties, and was not abstract, potential and unformed' (vi.206/207). Primary matter is 'self-subsisting, and other things subsist through it . . . and we should hold that matter (whatever it is) is so adorned, prepared and formed that every virtue, essence, action and natural motion may be the consequence and emanation of it' (vi.208/209).

At this point, Bacon comes to the main aim of *De Principiis* (albeit a largely unrealised one, as the work is far from complete), namely, the critical examination of various views on the fundamental principles of nature. He distinguishes four schools of thought on this question: first, those who hold there is a single principle which is able to produce a

diversity of entities (Thales and Anaximenes); second, those who hold that there is a single principle which may take a variety of magnitudes, shapes, and positions (i.e., atomism, which posits one kind of matter and explains changes in terms of the different sizes and motions of material atoms); third, those who hold that there is more than one principle of things, these principles explaining the diversity in nature (Parmenides and Telesio); and fourth, those who hold that there are infinitely or indefinitely many principles of things (Anaximander). Of these alternatives, he tells us,

the second sect alone seems to me to represent Cupid as he really is, native and naked. But the first introduces him as separated by a veil, the third as wearing a tunic, the fourth indeed as cloaked and almost masked. (vi.210/211)

Bacon can find no one in the first school who held that earth was the first principle, but Thales held that water was the principle of all things, Anaximenes held air was, and Heraclitus held that fire was the first principle (vi.210–18/211–19). His criticisms of such one-principle theories rest largely on the lack of a real rationale in choosing one of the elements over the others (vi.220/221). Moreover, on closer examination, the principles seem to rest not on real water, air, and fire, but upon ‘some notional and fantastic fire, air, or whatever, which keeps the name of fire etc. but does not answer the definition of it’ (vi.220/221). Indeed, Bacon suggests that these one-principle accounts really offer little advantage over ‘abstract matter’ theories, by which he presumably means Aristotle’s doctrine of prime matter. Another problem is the difficulty such accounts have in explaining the existence of contraries in nature:

But since such great armies of contraries appear throughout the universe, as of dense and rare, hot and cold, light and dark, animate and inanimate, and very many others, which attack, usurp, and slaughter one another in turn, to suppose that all these spring from some one source of material stuff, but still not disclose any of that stuff’s mode of action, seems a kind of frantic speculation and a giving up of inquiry. (vi.222/223)

If there were indeed one principle of things, we should expect to find it in all things, but we do not; we should expect to find it centrally located (as the Earth is), but we do not; we should expect it to be responsible for the generation and corruption of things, which air and fire are clearly not, and things which putrefy do not reduce to pure water (vi.222–4/223–5), so none of these is appropriate.

The remainder of *De Principiis* is devoted to the third school. He mentions Parmenides and Plutarch in this respect, but it is Telesio who is singled out, and his natural philosophy is – unusually for Bacon – examined in some detail. He sets out Telesio’s doctrine, which he claims

derives largely from Plutarch's lost treatise *De primo frigido*, in the following terms:

The primary forms and the primary active entities, and therefore the primary substances, are heat and cold; these exist no less incorporeally, but underlie a passive and potential matter, which furnishes corporeal mass and is subject to both natures alike, but is quite devoid of action itself; light is a burgeoning of heat, but dissipated heat, which, multiplied by coming together, becomes robust and perceptible. Darkness is similarly a desertion and confusion of the radiating nature caused by cold; rarity and density are the textures and as it were the webs of heat and cold; indeed, heat and cold are their originators and fabricators, cold condensing and thickening the work, heat separating and thinning it; from such textures bodies acquire a disposition ready for or hostile to motion, that is, ready and willing in rare bodies, hostile and inactive in dense. Therefore heat by tenuity excites and creates motion, cold by density curbs it and quietens it down. (vi.224-6/225-7)

This account of the nature of matter furnishes Telesio with a distinctive cosmology, and Bacon takes over much of this cosmology, effectively making it his own, in the *Descriptio* and *Thema Caeli*, as well as in *De Principiis*. Briefly, the immobility of the Earth is put down to its coldness, whereas the mobility of the Sun and the stars is due to the fact that they are very hot. Terrestrial fire requires a constant input of fuel because it is out of its natural place; celestial fire, on the contrary, is 'kept going by itself and things like it' (vi.226/227). The regions between stars are filled with a thin fluid substance, allowing the transmission of light from distant stars, and the motion of the heavens is that 'appropriate to the most mobile body', namely rotation, although speeds may vary as a function of distance from the centre, and the innermost planets may describe spirals rather than true circles (vi.228/229). Bacon's account of Telesio's theory of the formation of the Earth's crust and of the nature of the Earth's core are much as we find them in Bacon's own theory in the *Descriptio*. Telesian cosmology, on Bacon's construal of it, works in terms of a struggle between the two basic principles of heat and cold, represented by the Sun and the Earth; cosmic processes such as the rotation of the heavens around the Earth, as well as terrestrial phenomena such as the cycle of the seasons and the change of temperature with change in latitude, are explained in terms of this struggle, as are the different properties of various materials.⁴²

Bacon's criticisms of Telesio's account are perceptive. He notes, for example, that Telesio 'finishes up in despair and wishful thinking', for although he maintains that we can determine the 'power and amount of heat, and the disposition of matter', he concludes that 'nevertheless

42 Later, at *De Princ.*: BW vi.256/257, Bacon explicitly criticises Telesio's idea that the Earth can be set up 'as the contrary active principle to the heaven.'

their exact and precise relations, and their distinct and as it were quantified modes, lie beyond the threshold of human inquiry' (vi.246/247). But his most distinctively Baconian criticism is that Telesio's account would be plausible only

if man along with the mechanical arts which vex matter were removed from nature, and the fabric of the world were regarded artlessly. For his seems a kind of pastoral philosophy which contemplates the world calmly and as if in idleness. (vi.250/251)

He is also concerned, though, with the theological credentials of Telesio's system, in which nature might easily have been eternal. We know three things from Holy Writ – that matter is created out of nothing, that structure does not develop internally from within but was imposed upon it by the word of God, and third, 'that this schematism was (before the Fall) the best of those which matter (as it had been created) could support' (vi.250–2/251–3) – and any legitimate natural philosophy must accommodate itself to these revealed truths.

The move from Telesio's two-principle system to atomism is pursued in terms of the question of what can be made out of what. Entities can only be made out of entities, Bacon tells us, and principles can only be made out of principles. Telesio, however, wants to construct entities, namely material objects, out of abstract principles, heat and cold, which is just not possible, and it is this kind of consideration that has driven philosophers to atomism, for the atom 'is a true entity, having matter, form, dimension, place, resistance, appetite, motion and emanation' (vi.252/253). Atoms remain constant beneath the changing macroscopic phenomena, and it is these, rather than eternal principles, that provide the basis for the physical behaviour of bodies (vi.252–4/253–5).

Bacon offers four basic objections to Telesio's account, which he sees as summing up the insuperable difficulties it encounters. First, there are certain actions in things which cannot be referred to the principles of heat and cold at all. Second, heat and cold are the effects of some processes rather than their causes. Third, even those processes that do originate in heat and cold derive from them by means of 'their efficient and instrumental cause, not as if from their proper and intimate one.' Fourth, he maintains that 'this conjunction of four connatural things is altogether mixed up and confused' (vi.256–8/257–9). He does not develop the third and fourth points in any detail, and in the fourth is somewhat obscure as it stands. His brief discussion of connatural things criticises the idea that like attracts like, or, as he puts it, the idea that 'bodies seek the greater masses or congregations of their connaturals' (vi.266/267). He focuses on Aristotle's doctrine that heavy bodies are carried downwards by a natural motion, pointing out that there could not possibly be any explanatory value in such an account.

One thing that *De Principiis* brings out very clearly is the degree of Bacon's indebtedness to Telesio for the basic principles of his natural philosophy, despite his protestations to the contrary. What he does, effectively, is to appropriate (what he takes to be) a Telesian natural philosophy, and to replace its underlying matter theory with atomism, leaving the vast bulk of that natural philosophy unchanged. Like Telesio, he sees natural philosophy as being driven by a theory of matter, as opposed to a theory of motion. Moreover, he takes heat and cold to regulate cosmology, but not exclusively so, as Telesio does, making pressure and related notions do some of the work that heat does in Telesio's system.

The details of the resulting system are worked out around 1611 as Bacon embarks upon a concerted attempt to set out a comprehensive matter theory. Whereas in the earlier *Valerius Terminus* and *Cogitationes de Natura Rerum* he had stressed the importance of motion – the discovery of the different kinds of motion lies at the foundation of his natural philosophy there – it is now the nature of matter that lies at the most fundamental level, and he explains the motion of the celestial bodies, for example, very much in terms of the matter of which they are composed, as if an understanding of their material composition were necessary, and perhaps sufficient, to account for their motion.

A theory of the cosmos

Bacon's matter theory is set out in most detail in a series of writings which provide a cosmological context for his theory, probably all dating from 1611 and 1612. These are, to give them in their probable order of composition, *Phænomena Universi*, *De Fluxu et Refluxu Maris*, *Descriptio Globi Intellectualis*, and *Thema Cæli*. We can most usefully begin with the most general and schematic description of Bacon's project, that set out at the beginning of the *Descriptio Globi Intellectualis*. The *Descriptio* is a revision of Book 2 of the *Advancement of Learning*, undertaken as part of Bacon's plan to issue an expanded Latin version of the whole work, although this task would not be completed for another ten years. A radical expansion of content occurs in the discussion of 'natural history', which he divides up into natural processes ('of generations'), marvels or monsters in nature ('of pretergeneration'), and nature altered by human beings ('of arts'). Natural history, he writes, should be the foundation of philosophy, and it comprises the third part of his 'Great Instauration'.⁴³ What he now proceeds to set out in the *Descriptio* is a detailed account of the first part of the tripartite subdivision of natural history, namely natural processes. There are basically five kinds of natural pro-

43 *Glob. Intell.*: BW vi.108/109.

cess on Bacon's account, and he refers to them as: first, the 'ether', by which he means an account of the heavens; second, 'meteors' or 'regions of the air' (including comets); third, the 'Earth and the Sea', which he considers to form a single system; fourth, the 'elements', that is, the ultimate constituents of things; and fifth, the 'species' of things, that is, those kinds of things that nature marks out.⁴⁴ He then sets out what he sees as the principal accompanying topics, and where they might come in his schema:

As for those Virtues which may be reckoned as Cardinal and Catholic in nature, – such as Dense, Rare, Light, Heavy, Hot, Cold, Consistent, Fluid, Similar, Dissimilar, Specific, Organic and the like, together with motions going to make them, as resistance, connection, coming together, expansion and the rest (the history of which I want absolutely to be compiled and put together, even before I come to the work of the Intellect) – I shall deal with the history of these virtues and motions, and the way of putting it together, after I have finished explaining that threefold partition of Generations, Pretergenerations and Arts. For I have not, of course, included it within that threefold partition of mine, because it is not properly history but a middle term so to speak, between history and philosophy. (*Glob. Intell.*: BW vi.108–10/109–11)

The fragment of the *Descriptio* that he managed to complete contains an account of only the first part of the five-part division of natural processes, namely the heavens. This account is filled out and developed further in *Thema Cæli*, and in passages in the *Phænomena Universi*. The third subdivision, the 'Earth and the Sea', is developed further in *De Fluxu et Refluxu Maris* and in passages in the *Phænomena Universi*, which also deals with one of the 'virtues', namely the question of rarity and density. None of the other topics is discussed in its own right.

It will be useful to begin by looking at *Phænomena Universi*, returning to the *Descriptio* below, because *Phænomena Universi* fills out the general picture presented at the beginning of the *Descriptio* by providing an overall account of Bacon's matter theory, and it leads directly into more general questions of cosmology. It also provides an opportunity for us to clarify just what 'natural history' amounts to for Bacon. The work is subtitled 'natural history for the building up of philosophy', but Bacon draws a sharp distinction between what he has in mind and what had traditionally gone under that name. He mentions classical figures such as Aristotle, Pliny, and Dioscorides, but names few modern naturalists: He refers only to Gesner, a prolific writer on natural history,⁴⁵ Agricola,

44 Ibid.

45 Conrad Gesner wrote a number of works in natural history, including a five-volume *Historiæ Animalium* which came out in Zürich between 1551 and 1587.

whose *De Re Metallica* was the first modern work on mining,⁴⁶ and José de Acosta – whose *Historia natural y moral de las Indias* (1590), translated into English in 1604,⁴⁷ provides one of the first comprehensive accounts of the natural history of South America – but he fails to mention many other equally famous naturalists, including the most famous of them all, the ornithologist Ulisse Aldrovandi.⁴⁸ On the other hand, his discussions of natural history occasionally draw on a group one might naturally consider to be more marginal to the enterprise: Patrizi, Telesio, Cardano, della Porta, Bruno, and Paracelsus. Remarking on this, Paula Findlen has noted that ‘for anyone versed in the natural history tradition, Bacon’s own natural history seems strikingly devoid of the common markers that we associate with this genre: no lengthy descriptions of flora and fauna; no discussions of etymology, number of toes and fronds, or other classificatory devices.’⁴⁹ The reason, as she points out, is that Bacon wanted to redefine natural history, which he saw as including, and perhaps being constituted primarily of, a mixture of natural magic and alchemy. He tells us at the beginning of the *Phænomena* that the natural history that has been compiled hitherto ‘is sketchy and useless, and not even of the kind I am seeking’.⁵⁰ Its principal defect and, we may conclude, the feature that makes it ‘not even of the kind’ he is seeking, is the fact that ‘it has embraced the inquiry into things natural but largely spurned that into things mechanical’ (vi.4/5). The latter, he tells us, enable us to go beyond the effects of nature and probe its secrets, although its practitioners have concentrated on things ‘hidden and rare’ at the expense of ‘common experiments and observations’. The central failing of natural history, however, is that it has been pursued ‘either for the usefulness of the experiments themselves, or for the agreeableness of their narratives, and to have been made for their own sake, not so as to furnish the makings of philosophy and the sciences’ (vi.4/5). What Bacon wants to do is to establish a connection between his newly conceived natural history – that is, natural magic and alchemy relabelled, perhaps

46 Georgius Agricola, *De Re Metallica Libri XII* (Basel, 1556).

47 José de Acosta, *The Natural and Moral History of the Indies*, trans. Edward Grimston (London, 1604).

48 Ulisse Aldrovandi, *Ornithologiæ, Hoc Est, de Avibus* (Bologna, 1599/1600); *Ornithologiæ Tomus Alter de Avibus* (Bologna, 1602); *Ornithologiæ Tomus Tertius* (Bologna, 1603).

49 Paula Findlen, ‘Francis Bacon and the Reform of Natural History in the Seventeenth Century’, in Donald R. Kelley, ed., *History and the Disciplines: The Reclassification of Knowledge in Early Modern Europe* (Rochester, 1997), 239–60, at 240.

50 *Ph. Univ.*: BW vi.2–4/5. Subsequent citations in this section to *Phænomena Universi* will be given parenthetically in the text solely by BW volume and page.

in order to give them some air of respectability⁵¹ – and natural philosophy as traditionally conceived, that is, as a *scientia* which offers a fundamental understanding of nature.

Natural history is defined as dealing with the natures of things, depending on whether these are free, as in natural species, disturbed, as in monsters, or confined, as in experiments (vi.8/9). This leaves three parts of the discipline. The first two, history of species, ‘as for example of plants, animals, metals, and fossils’, and history of marvels, would have made up what was traditionally regarded as natural history.⁵² The former Bacon regards as ‘puffed up and full of curiosities’ and should be curbed, whereas the latter is ‘empty and based on rumour’ and needs to be ‘purified and sifted’. The third, the history of experiments, which would fall outside natural history as traditionally conceived, is defective, piecemeal, careless, and practical as opposed to philosophical. To remedy the failings of this newly defined natural history, Bacon tells us we must ‘hold fast to the ways of true and good induction’ (vi.4/5). We must not be misled by the view that inquiry into particulars ‘is something infinite and without end’ for, on the contrary, it is the only enterprise that allows us to proceed with certainty (if properly pursued); nor must we accept the view that we will be dealing with things which are beneath the dignity of the human mind, for these things are examined not for their own sake, but because they are the only route to understanding (vi.6/7).

He begins his inquiries into natural history/natural philosophy by dealing with the most fundamental constituents of nature, that is, with those things ‘which make up and answer to a nature more general, in which both globes share’ (vi.10/11). By contrast with the Aristotelian tradition, for example, Bacon simply states that the terrestrial and celestial spheres contain the same kind of matter, and that one crucial feature

51 Compare Findlen, ‘Francis Bacon and the Reform of Natural History’, 241: Natural history had come to mean something quite different to Bacon than it had traditionally connoted; like natural philosophy it was in need of reinvention. . . . [Natural history] provided a rubric under which to pursue forms of inquiry that were incapable of full redemption in their current state. It provided the *via media* between the academically exalted field of natural philosophy and both the occult sciences and the crafts tradition. . . . Drawing upon these various fields of knowledge and sanitizing them through their relabelling as ‘natural history’, Bacon strove to create an approach to nature that would make its study and its practitioners more deserving of public recognition.

52 This conception of natural history, as dealing with natural phenomena as opposed to the products of human artifice – and so including animals, plants, and minerals – was a dominant conception up until the first decade of the nineteenth century, when biology, which effectively begins with the formulation of the distinction between the living and the nonliving, comes into existence.

of the makeup of both spheres is the concentration of matter in particular bodies, that is, their rarity or density. Since the sum total of matter is constant, and some bodies contain more matter in the same volume than others, the amount of matter per unit space in various bodies should be something that can, in the normal course of events, be definitely determined. Taking the volume of one ounce of gold as the standard, Bacon proceeds to weigh different substances, taking that amount of each substance – pressed into a cube the size of the gold or poured into the cubical container that contained the gold when it was weighed – which takes up as much volume as the ounce of gold. He lists the densities or specific weights of seventy-three different kinds of material, starting with the densest, gold, and moving down to fir wood, which is just under a hundred times lighter. He describes how he took the measurements, and provides some suggestions for further investigation, such as finding out whether compressed bodies register a greater weight than their matter would warrant, and how one might deal with bodies (such as leaves) which cannot be squeezed into the shape of a cube (vi.20–2/21–3). He finds that vegetable matter is the lightest of all substances, its density being even less than that of very refined oils, and that bones and flesh are more compact than wood and leaves. He concludes from his table of densities that sulphur cannot be ‘the father of all metals’, as many take it to be, because it is rarer than any of the metals – although when mixed with mercury, the density of the mixture can equal that of any of the other metals except gold, since mercury is almost as dense as gold, and nearly twice as dense as the next densest metal, lead (vi.26/27).

The results on specific weights are used as a basis for distinguishing different kinds of material; so, for example, he is able to show that crystal is not a form of condensed or congealed ice because the specific weights of ice and crystal are very different (vi.26/27). (It is worth remembering in this context that the ‘crystalline spheres’ holding the planets and so on in their orbits had often been thought to be composed of ice.) However, he also raises open-ended questions about the relation between the physical processes by which bodies are formed and the density that they have, asking, for example, whether there is any relation between the specific weights of metals and the depths at which they are found, or whether the intensity of the process needed to form a substance (such as the intense heat needed in the production of glass) is reflected in its specific weight. He also notes that the ways in which liquids combine does not depend at all on their relative specific weights, for spirit of wine floats on pressed almond oil, even though their specific weights are very similar, whereas it mixes with water, despite the fact that there is a significant difference between their specific weights (vi.28/29). Refining his experiment, he draws attention to the differences between substances and the powders or residues formed from them. As

often as not, the powders are in fact oxides or other compounds which, as he discovers, have a considerably smaller specific weight. He is aware that different processes are responsible for the differences here, and he tells us that 'the value of a powder which comes from simple crushing or filing is one thing; another that which comes from distillation, as in sublimates; another which comes from strong waters and corrosion, turning them, as it were, into rust; and another which comes from burning, as ashes and calx' (vi.32/33). Nevertheless, he does offer a comparative listing of the specific weights of substances in solid form with the specific weights of their 'powders' – mercury with mercury sublimate, lead with white lead powder, oak wood with its ash – as if the different processes by which the powders are formed is just a complication that can be taken into account later, giving the impression that, at least at some level of approximation, he is comparing the specific weights of substances in solid and in powder form, which of course he is not.⁵³ Moreover, he is led by this to draw a wholly illegitimate conclusion, namely, that the far greater specific weight of solids with respect to their compressed powders shows that 'in more compact bodies there is a far closer compaction of parts than can be matched by any arrangement or compression of their powders' (vi.32/33).

Later, in his *Historia Densi et Rari*, he develops some of this material on specific weights in a more ambitious way, arguing that there are limits to the rarity or density of things, although these are not manifest in any body known to us.⁵⁴ He denies that there is a vacuum in nature, either between the parts of the matter making up bodies or between bodies; rather, he tells us, matter is able to fold and unfold without creating a vacuum, although it is far from clear how we are to understand spatial dimensions on this image. His figures for specific weights of a range of tangible materials from gold to oils and woods indicate that the variation in density is not greater than 32 to 1, and he estimates that the difference between the rarest tangible body and the densest pneumatic body (which he sets out to measure in an experiment in which wine is heated and vaporised into a deflated bladder)⁵⁵ is of the order of magnitude of 100 to 1. He argues that flame is rarer than air, oil than water, and that flame is not rarefied air, nor air rarefied water, but that they are antithetical heterogeneous bodies.

The remainder of the *Phenomena Universi* is devoted to the behaviour of fluids, principally water and air. His first concern is with the question

53 His account of these processes is extremely perfunctory: See *Ph. Univ.*: BW vi.32–4/33–5.

54 Nevertheless, it seems safe to assume from his cosmology that they would be manifested at the centre of the earth and in celestial bodies, respectively.

55 *Dens. & Rar.*: Works ii.257–8/v.353–4.

of how bodies can propel themselves through these fluid media: how birds can propel themselves through air, for example, and how oars can propel boats through water. What happens in these cases is that when fluids are squeezed into confined spaces, as in the case where they are immediately behind the wings and immediately behind the oar when these push backwards, they exert a force which acts in the opposite direction to the motion of the wing or the oar, with the result that the bird or the boat is pushed forwards by the air or the water, which, as a result of the initial compression, expands in the direction of its motion (vi.36–40/37–41).⁵⁶ He looks at cases of the generation of sounds by air pressure, the effects of forcing water under narrow arches, the behaviour of upturned bowls of air submerged in water, the mechanism of bellows, and various other phenomena that point to the effects of pressure on fluids. He distinguishes, in particular, between two kinds of case: motion 'to avoid a vacuum' and 'motion of recovery from tension' (vi.46/47), describing a number of experiments to separate out their effects.

In general terms, what Bacon is offering is an account of different kinds of motion in terms of the compression of an elastic medium, where compression is filled out in terms of changes to the density of a substance, thereby making matter theory fundamental to any account of motion. This is made evident in his discussion of the heavens in the *Descriptio*, which begins with a statement of his aim: He says he wants to work back from the astronomical information provided in writers like Ptolemy and Copernicus to the bare observations, with the goal of starting afresh from this information,

for I do not merely have calculations or predictions in mind, but philosophy; that is, that which can inform the human intellect not only about celestial motion and its periods but also about the substance of the heavenly bodies and every sort of quality, power and influx, according to natural and incontrovertible reasons and without the superstition and frivolity of traditions; and again that can discover and unfold in the very motion not just what saves the phenomena, but what is found in the bowels of nature and is actually and really true. (*BW* vi.110/111)⁵⁷

56 This kind of account would be difficult to reconcile with a traditional form of atomism whereby the density of bodies was a function of the distribution of atoms, so that compression was merely a decrease in the size of the interparticulate vacua: For why would such atoms react to this by returning to their original distance from one another, unless there were a repulsive force between them, which, so far as I can tell, no atomist had postulated? It is possibly because elasticity is such a fundamental physical notion for Bacon that he does not allow interparticulate vacua, although this rejection will only be spelled out explicitly later.

57 Subsequent citations in this section to *Descriptio Globi Intellectualis* will be given parenthetically in the text solely by *BW* volume and page.

One thing this indicates is that matter theory is going to play a central role, and Bacon proceeds to point out that the distinction between the etherial and sublunary spheres is completely artificial, since there can be no doubt that basic processes such as 'expansion, contraction, impression, giving way, congregation in masses, attraction, repulsion, assimilation, union and the like' occur everywhere. He then goes on to make a much stronger claim: that everyone who knows 'the catholic passions of matter and through these knows what may be, cannot but know also what has been, what is and what will be, according to the sums of things' (vi.112/113). On the face of it, this looks like a statement of Laplacian determinism – whereby if one knows certain basic information about the universe at some time (such as the position and momentum of every particle in the universe), then one can predict all its future states, and retrodict all its past states – but it seems unlikely that he would introduce something quite so radical without further comment, and the meaning is probably closer to the claim that knowing the material constitution of the universe, one knows something sufficiently fundamental that one is able to understand all other physical changes. This is confirmed in the next sentence, where the conclusion he draws from this is that 'the best hope and assurance for reflection upon the heavenly bodies lies in physical reasons' (vi.112/113). Moreover, he refers to Proteus as someone who knows past, present, and future, and it is worth bearing in mind here the discussion in *De Sapientia Veterum*, where we are told that Proteus is a shepherd whose sheep are the different forms or species taken by matter.⁵⁸ After counting them, he falls asleep, indicating that no new species are being formed in nature; but we can force him to reveal at least some of his knowledge, allowing us to form new species in nature ourselves. In other words, it is the transition from nature being the sole source of new species to our having the power to form new species that is at issue here, and I have no doubt that the same idea underlies the mention of Proteus in the *Descriptio*.

He proceeds next to the question of whether the universe forms a single system, that is, whether it 'is one single globe, of which there is some centre' (vi.116/117). The contrary opinion is that the Earth is simply a movable planet, and that individual planets and stars are scattered throughout the cosmos, revolving not around a common centre but around various bodies, with various kinds of motion. Against this view, Bacon puts forward the peculiar argument that, just as there are bodies which revolve, so there ought to be bodies at rest, and bodies in between these two extremes, which move in straight lines. Happily, he does not regard this as deciding the matter; rather, he takes the question of whether the universe is a single system to rest on the mobility or otherwise of

⁵⁸ *De Sap. Vet.*: Works vi.651/725–6.

the Earth. If the Earth is stationary and the heavens revolve around it daily, then the universe is indeed a system; if it is not, then of course there may be some other centre, such as the Sun – but if we can establish the former view, then we need look no further, and this is exactly what Bacon sets out to do. He also aims to show what he takes to be two correlative theses. The first of these is that the Earth is the only ‘dense and solid’ sphere, that the ‘matter of the universe is concentrated and condensed to that centre’ (vi.120/121). The second is that there is a concentration of matter towards the centre, the interplanetary ether thinning out as one moves out from the centre; this is in contrast to what one would expect in a nonhomocentric system, namely, that each celestial body would be surrounded with its own effluvia, which would thin out the further one got from that body, the result being that one would have multiple variations in density, instead of a single gradient.

On the question of whether it is the Earth or the Sun that is at the centre of a homocentric cosmos, the trouble with having the Sun at the centre, as Copernicus does, is that one then needs to explain why all the other stars should not be centres of their own systems (vi.122/123).⁵⁹ As regards the outer periphery of the cosmos, the fact that the stars rotate at the same speed ‘and so to speak with one spirit’ around the Earth indicates that they are located in a single region, which revolves, with its contents, as one (vi.122–4/123–5).

On the question of what connects the parts of the system, Bacon sets out three possibilities: In the interstellar spaces, there is either a vacuum, or contiguity, or continuity (vi.124/125). The first view, that of some of the ancients and of Gilbert, is that both stars and the Earth are solid bodies which emit effluvia or emanations, such as the air in the case of the Earth, that surround the body but do not extend to any great distance beyond its surface. The result is that by far the greater part of the interstellar spaces are empty of any matter, something which seems supported by the fact that we can see the stars clearly, whereas if there were matter between the Earth and the stars, it would pose a significant obstacle to light rays. But this depends, Bacon points out, on the nature of the matter, ‘whether it is dense, or thin and unfolded.’ His minimal point is that we do not need to introduce the hypothesis of a vacuum to explain the visual clarity of the fixed stars, only to note that the nature of stars is ‘thin and flamy’. In effect, what he seems to be implying is that whatever can be explained by a vacuum can also be explained by matter thinly spread throughout the interstellar spaces. He makes clear that the grounds on which one might postulate the existence of interparticulate

59 A number of natural philosophers had drawn the conclusion that an infinite universe cannot have a centre, including Nicholas of Cusa, Rheticus, Thomas Digges, and Bruno.

vacua (a common enough atomist assumption, and indeed a sine qua non of atomism for many) are stronger than those for a 'collective vacuum', and Democritus, Leucippus, and Hero, for example, accept inter-particulate vacua but not a collective vacuum (vi.126/127).

There is, however, great diversity between different regions of the universe, which must prompt us to ask whether the ether is a continuous fluid or whether it comprises several contiguous fluids. Bacon makes it explicit that by 'contiguous fluids' he does not mean crystalline spheres – which Tycho Brahe had shown cannot exist, on the grounds that the paths of comets cross the regions supposedly separated by such spheres, as well as by arguing that the paths of planets cross that of the Sun⁶⁰ – but regions of genuine fluid, a widely held view by this time,⁶¹ which float upon one another 'as in the case where water floats on quicksilver, oil on water and air on oil' (vi.128/129). Noting that the water at deeper levels of the sea has a different consistency and taste from that at the surface, and that there is a difference in consistency between the air close to the Earth and that higher up, he argues that the question at issue is whether there are distinct boundaries or whether there is a continuous gradation of matter. Bacon opts for the former, for 'no structure of things or organic shape could be established if the process always went on by imperceptible degrees' (vi.128/129). This is evident on the Earth, where the boundary between water and air, and the ground and air, is a sharp one. More generally, he tells us, there are three regions between the surface of the Earth and the farthest reaches of the heavens, namely 'the tract of the air, the tract of the planetary heaven and the tract of the starry heaven' (vi.128/129).

The final, and longest, chapter of the *Descriptio* concerns the material constitution of the stars and the interplanetary ether. This is a core question for Bacon, for 'inquiry concerning the substance of heavenly bodies belongs particularly to philosophy, as does the inquiry concerning the causes of their motion' (vi.134/135). Astronomical hypotheses are designed to make calculations as simple as possible, whereas philosophy must prefer those that 'come closest to the truth of nature', which means that the latter must have priority. In the present state of things, however, it is the former that have priority: 'the fictions of astronomy have been introduced into philosophy and debauched it.' The two must therefore be combined on a more rigorous footing, which matter theory provides. The first question to be asked is whether 'the substance of the heavenly bodies is different in kind from those below.' He rejects the Aristotelian

60 Tycho's reflections on this matter begin with the comet of 1577, but his account was first set out eleven years later in *De Mundi Ætherei Recentioribus Phænomenis* (Uraniburg, 1588).

61 See Donahue, 'Solid Planetary Spheres', 256ff.

view that the celestial realm is characterised by changelessness and the terrestrial realm by mutability. There are many elements in both that are immutable and many that are mutable: The Earth's core seems relatively immutable, for example, whereas the heavens produce new stars and comets. The main region of change, however, seems to be at the interface between the Earth and the heavens:

[I]t seems that almost all the tumult, conflict and disruption take place only at the boundaries of the heaven and Earth, just as happens in political affairs, in which we often find that the borders of two kingdoms are afflicted by continual incursions and violence, while the interior provinces of each kingdom enjoy prolonged peace, and are disturbed only by greater and rarer wars. (vi.148/149)

As for the interstellar spaces, these are either void, a theory already rejected, 'or filled with a body which is to the stars what air is to flame', or they are 'filled with a body homogeneous with the stars themselves, lucid and so to speak empyrean but to a lower degree, i.e. with a light not so radiant and vibrant' (vi.150/151). Bacon argues for the last option, following Telesio in noting that ordinary air 'contains something of light within itself', this being the explanation of how some animals can see in the dark.

On the question of the concentration of matter in the universe, Bacon considers Gilbert's view that it is unlikely that all compact matter is crammed into the Earth, and that the Moon and many other celestial bodies, including the Sun, are composed of densely packed matter also. Bacon admits that telescopic observation does show the Moon to have surface markings indicating a solid body; but he finds little reason to extend this reasoning to other celestial bodies. This question seems ultimately to turn on 'which of the stars give out primitive light originating from themselves, and which again light from the Sun – of which the former seem to be cosubstantial with the Sun, the latter with the Moon' (vi.156/157). Moreover, we need to discover whether the light of the stars is caused by the same kind of fire with which we are familiar on Earth, and in this respect we must not be misled by apparent differences in behaviour between celestial and terrestrial fire; for fire placed in the ether and in great quantities, such as we find in the stars, may behave very differently from how it behaves on Earth, just as water in large masses ebbs and flows, whereas in smaller quantities it does not. Still, Bacon does concede that there must be some difference between stellar fire and terrestrial fire, for they differ also in substance. Stellar fire is 'pure, intact, and native'; terrestrial fire is 'degenerate, . . . out of place, cowering, surrounded by contrary bodies, in need, begging alms for food to support itself, and fugitive', whereas fire in the heavens is in its proper place, and so can carry out its operations 'freely and without

interference' (vi.158/159). Terrestrial flame is 'pyramidal', that is, tapers to a point at its exterior, because it is compressed by the air, but its interior is 'globular', like stellar flame (vi.160/161). But how does stellar flame arise? Does the flame need to be fed, as do terrestrial ones, constantly consuming new material? Bacon argues that, because of the conservation of matter, when something disappears, it is replaced by something else, and that this process happens in the interior of bodies, in the Earth as much as in the stars, in a very different way from the regions at the peripheries of these bodies. Yet there is an apparent variation in the size of celestial bodies, whereas the Earth does not vary in this respect. This apparent 'stellar variability may be ascribed either to distance and proximity (as in planetary apogees and perigrees), or to the constitution of the medium' (vi.162/163). Bacon considers that the latter would not fully explain the variations in the size and shape of Venus. Indeed, his treatment of the variation in the size of Venus is characteristic of his whole approach: Rather than asking what variations in the planet's motion would account for these variations in size, he proceeds instead to what he regards as a closely connected question, namely, whether celestial bodies come into and go out of existence – as if changes in size were a kind of limiting case of coming into and going out of existence – and he tells us he will postpone treatment of this issue until he looks at comets (vi.164/165).

The account in the *Descriptio* ends with a criticism of astronomers' attempts to calculate the magnitudes of stars, an assertion of their spherical nature, and a few remarks on the controversial nature of calculations of the distance of stars (vi.166–8/167–9). Much the material pursued in the later parts of the *Descriptio* is taken up in *Thema Cæli*, however, which is in many respects a continuation of the *Descriptio*, completing Bacon's discussion of the first subdivision, the 'ether'; but it does more than this, for it offers a more elaborate account of the matter theory underlying his astronomy and cosmology.

Bacon starts from the idea that matter is distributed in the cosmos in such a way that gross matter – that of tangible substances – is confined to the sphere of the Earth, and beyond its surface there is only fine or subtle matter, what he terms 'pneumatic substances'.⁶² Tangible and pneumatic substances form the two fundamental substances from which all else is composed. Air and flame are the two basic pneumatic substances, he tells us, and they are fundamentally different; the difference 'derives from the condition of things which is the simplest of all, that is, the abundance and scarcity of matter in proportion to its bulk', that is, density. To air correspond four forms, depending on the altitude. Within

62 *Th. Cæli*: BW vi.172/173. Subsequent citations in this section to *Thema Cæli* will be given parenthetically in the text solely by BW volume and page.

the Earth it takes the form of mercury, at its surface it takes the form of water, immediately above its surface it takes the form of air proper, and beyond that the form of the ether. There is a similar division of flame: Within the Earth it takes the form of sulphur, at its surface it takes the form of oil, above its surface it takes the form of terrestrial fire, and beyond that the form of sidereal fire (vi.172/173). The first two in each case are tangible substances, the latter two pneumatic substances. Everything else is a composite body, including salts – a clear repudiation of Paracelsus.⁶³

Bacon argues that there are three regions between the Earth and the periphery of the cosmos, as indicated by the behaviour of flame (vi.172–6/173–7). On the Earth, flame is easily extinguished; but as one moves outwards from its surface, it lasts longer, something Bacon takes to be evident in some comets, until it reaches the Moon, where flame is no longer extinguishable, although reacting with the ether, it still has reduced power. Flame is stronger in Mercury, and stronger still in Venus. It reaches its full force in the Sun, with Mars still showing vigorous fire, but it becomes ‘calmer and whiter’ as one approaches Jupiter, and grows weak and feeble again by Saturn. Bacon associates this behaviour with separate identifiable regions:

Therefore we find three general regions between the Earth and the heights of the heaven, and as it were three layers in respect of the flamy nature: the region of flame’s extinction, the region of its union, and the region of its dispersion. (vi.176/177)

The distinction of regions prompts him to ask about the distinctness of their boundaries, and he reasserts the claim of the *Descriptio* that these are not continuous, but separate contiguous regions. He sets out his theory ‘about the substances of the System’ in terms of its main theses: It holds that air and flame are as separate from one another as are water and oil, and sulphur and mercury; it denies Gilbert’s idea that there is a ‘collective vacuum’ between the Earth and the Moon, maintaining instead that this space is ‘filled with either an airy or a flamy nature’; it denies that ‘the Moon is either an aqueous or a dense or solid object, affirming that Io is of a flamy nature though sluggish and weak’; it holds that flame ‘in its proper place and left to itself is fixed and constant no less than air or water, and that it is not as it is here with us, i.e. something transitory, and successive in its mass only through renovation and aliment’; it holds that flame ‘has a nature that attracts or gathers itself into globes’, which makes it similar to earth but different from air and

63 Later, in the sixth part of the projected third part of the ‘Great Instauration’, appended to *Historia Ventorum*, which deals with the alchemists’ triad of sulphur, mercury, and salt, Bacon indicates that he accepts only the first two as genuinely primitive elements (*Aditus: Works* ii.82–3/v.205–6).

water, that in the sidereal region it 'is distributed in infinite clusters' and that stars are real flames; and, finally, that 'the interstellar ether and the stars are related to each other as air is to flame, but sublimed and rectified' (vi.176-8/177-9).

Having set out his conception of the basic substances from which the cosmos is constructed, he proceeds next to their motions. The argument mirrors that of the *Descriptio*: The cosmos would not form a system unless there were something at rest in it, and this must be some concentration of matter, for which the Earth is the natural candidate. He praises Telesio for opposing heat, light, tenuity, and mobility against cold, darkness, density, and immobility (vi.178/179), and here we find matter theory firmly in control. If we grant rest and immobility, he tells us, we should also grant perfect mobility, that is, movement in a circle, a type of motion that has no limit, which we see in the rotation of celestial bodies. In asking what regulates this motion, Bacon tells us he will 'banish to calculations and tables the fancy mathematics (that motion be reduced to perfect circles, either eccentric or concentric), and the empty talk (that the Earth is in comparison to the heaven like a point, not like a quantity), and many other fictitious devices of the astronomers' (vi.180/181). He begins by distinguishing 'cosmical' motions, where the motion of a body is due to a motion of the whole cosmos, from 'mutual' motions, where the motion depends to some extent upon the motion of some other body or bodies. Accepting that the Earth is stationary at the centre of the cosmos, he reiterates his theory that the whole of the cosmos revolves around the Earth, but adds that 'the further we depart from the upper regions, the less perfect is this motion in respect of its slowness and also in respect of its deviation from circular motion.' The stellar periphery rotates once every twenty-four hours, but Saturn moves more slowly, and the difference is increased as we move in towards the Earth, so that 'the diurnal motion of the stellar heaven . . . is about one hour quicker than the diurnal motion of the Moon.' Bacon accounts for retrograde motions, which he claims are not real, in terms of these differences in speeds, and he puts retrograde motion down to 'an appearance which stems from the faster advance of the stellar heaven to the west, and the falling back of the planets to the east' (vi.180/181). However, planets move not only at unequal speeds but in different ways, for they

do not come back to the same point of the circle, and turn away to the north and south; the limits of this deflection are the tropics; and this deflection has landed us with the Oblique Circle and Difference of its Polarity, just as that inequality of swiftness landed us with the motion of resistance. (vi.182/183)

Bearing this in mind, all we need to save the phenomena, he tells us, is to assume that the outer planets follow tight spirals which approximate to circles, whereas the inner ones follow more open spirals. This portray-

al, which as we have seen originally derives from Alpetragius (although Bacon seems to associate it with Telesio), is enough, Bacon believes, to account for retrograde motions. Moreover, the westerly motion is not just a motion of the heavens, but is present on the surface of the Earth as well. This is an argument followed up in *De Fluxu et Refluxu Maris*, 'On the Tides', in which Bacon considers in detail two movements of fluid media, tides and winds, and attempts to show how these are to be accounted for in terms of matter theory, as opposed to Gilbert's account of the diurnal rotation of the Earth.

He begins *De Fluxu* by distinguishing five types of motion of the sea: first, the currents, and then four types of tidal motion. The tidal motions are set out as follows:

The *second* [motion of the sea, i.e. the first tidal motion, is] the great six-hourly motion of the sea, through which the waters alternately advance and retreat from the shores twice a day, not exactly, but with such a difference as to constitute the monthly cycle. Let the *third* be the monthly motion itself, which is nothing other than the aforementioned diurnal motion brought back to the same tides. Let the *fourth* be the half-monthly motion, by which the tides are higher at the new and full moons than at the quarters; and the *fifth* is half-yearly motion, by which the tides become exceptionally high at the equinoxes. (BW vi.64/65)⁶⁴

The second is what is more usually thought of as the daily cycle of the tides, with a high tide every twelve hours; the third is the monthly cycle whereby the tides lag behind one another fifty minutes each day until they are back in their original position; the fourth and fifth are as Bacon describes them.

Although he tells us that we should put currents, which are relatively random motions of water, to one side lest they confuse us in discussing the tides (vi.66/67), the inclusion of currents gives a good indication of the nature of Bacon's approach; for these would be omitted, as being a different kind of phenomenon, in accounts which explained the tides in terms of the Earth's rotation, or in terms of the gravitational attraction between the Moon and the Earth. For Bacon they are not the same as tidal motions, but nor are they wholly different in kind from them, as some aspects of tidal behaviour can be explained in the same way as currents, namely by means of compression and expansion of water. Currents, he tells us, are due to the squeezing of water into narrow channels, or being spread out into open spaces, or accelerated, or running over furrows on the sea floor, or being driven by winds, including seasonal winds, and so on. In short, currents 'are merely waters compressed or freed from compression' (vi.66/67).

64 Subsequent citations in this section to *De Fluxu et Refluxu Maris* will be given parenthetically in the text solely by BW volume and page.

Of tides proper, his main concern is with the first type – the daily cycle. This produces the ebb and flow of the sea, whereas the monthly cycle ‘only seems to set limits on and bring back that motion’, while the last two cycles serve ‘to increase and intensify it’ (vi.66/67). The last two are distinctive in one respect, however, in that they seem to consist in a general rising and falling of the sea: There is a general rise at the equinox and at new and full moons which, we are told, can be caused by either a ‘lifting up’ of the water, or an increase in the amount of water, or an expansion and rarefaction of the body of water. The first two alternatives being implausible, we must explain the half-monthly and half-yearly motions by expansion and rarefaction. The daily cycle, on the other hand, is clearly not to be explained in this way, for it is a progressive motion, not a simple swelling (vi.68–70/69–71).

The first question Bacon raises concerns the observation that the ebbs and flows of the tide as observed on the Florida coast and upon the European coast coincide; contrary to what one might expect, they ‘plainly rise and fall on both shores at the same time’ (vi.70/71). The explanation, he reasons, must be that the waters from the Indian Ocean are obstructed by Europe and the Americas, and as a result are squeezed through the Atlantic Ocean in a northerly direction, the forced motion reaching eastern and western shores at the same time. He concedes that the three latter cycles may be affected in one way or another by the motion of the Sun and the Moon, but the daily cycle is not. As regards the Moon, which is the contentious question here, he tells us that there is no correspondence between the daily tides and the waxing and waning of the Moon, or its altitude, or its situation at the meridian or elsewhere. Nevertheless, the fact that the diurnal motion is so regular, with a six-hourly pattern, clearly indicates something of its nature, and Bacon sets out the three questions that he considers need answering in the light of this:

The first of these is whether the diurnal motion stays within the confines of the heaven, or descends and insinuates itself into the lower regions. The second is whether the seas move regularly from east to west, as the heaven does. The third is from where and in what manner does that six-hourly reciprocation of the tides arise, which coincides with a quarter of the diurnal motion, but with the difference proportional to the motion of the Moon. (vi.74–6/75–7)

On the first question, Bacon presses his homocentric model, on which, as we have seen, there are no contrary or retrograde motions. There is a single rotation not just of the heavens, Bacon believes, but of the whole cosmos around the Earth, and this is the cause of the daily tides, for the motion which is immense in the sphere of Saturn, for example, is far slower the nearer one approaches the Earth, which alone is stationary.

In support of this he points out that the planets have a diurnal motion, and this must be natural to them: To assume otherwise is to commit oneself to the idea of a 'first mover' in each planet, or to the Earth's rotation, neither of which he regards as satisfactory from a physical point of view (vi.76/77). Yet this motion from east to west is evident even in comets below the Moon, so they still share in the motion of the ether. This cosmic motion is weakened considerably by the time we get to the level of the Earth, but it still remains in a diminished state in fluids. It is evident from the constant east-to-west breeze along the tropics, where the air moves around the Earth in the greatest circles, although it is so weak as not to be felt outside the tropics. In sum, the circulation of the cosmos in a westerly direction also explains winds and tides, for this circulation also exists at the terrestrial level, even though it is largely inhibited by a stationary Earth.⁶⁵

65 Bacon provides more detail on the winds in his *Historia Ventorum*, where he tells us that they are 'generally ranked among things mysterious and concealed' (*Hist. Vent.: Works* ii.19/v.139). Drawing on classical sources – such as Aristotle (or at least texts ascribed to Aristotle), Pliny, Gilbert, and above all *The Natural and Moral History of the Indies* of the Jesuit geographer José de Acosta, which appeared in English translation in 1604 – Bacon's treatment begins with a comprehensive classification of winds, which follows the usual classification at sea, into general winds, which always blow; periodical winds, which only blow at certain times; attendant winds, which blow frequently; and free winds, which blow irregularly. He sets out the information known about where and in what direction these winds blow, whether they are hot or cold, strong or mild, wet or dry, and so on (*Works* ii.25–38/v.145–59). He maintains that normal winds have three origins, deriving either from the middle region of the Earth, either before or after the collection of vapours into cloud; or from the hollows of the Earth; or from the swelling and expansion of the air. We must investigate these, as well as the origins of special kinds of winds: hurricanes and the like (*Works* ii.38–50/v.159–72). We can safely ignore supposed astrological determinants of winds, but we do need to know how meteors, earthquakes, showers, and so on affect them, and how terrestrial conditions affect them: melting of snow and icebergs, soil conditions, 'burning of heath and the like for the cultivation of land; the draining of marshes', and so on (*Works* ii.22/v.142). Next he looks at procedures for recording whether winds travel large distances, or are relatively local, what their effect on tides is, and what information has been collected in these respects (*Works* ii.51–73/v.172–94). He remarks that we must investigate whether winds 'purify and infect the air with respect to pestilences, epidemics, and affections of animals' (*Works* ii.24/v.144–5). Finally, he points out that we must investigate natural 'imitations of winds', such as flatulence in animals, and artificial winds, such as those produced by bellows, and sets out to draw together all the information he can on these questions (*Works* ii.73–8/v.194–200). Bacon's work on the winds was taken up and developed in Thomas Bowman, *A Discourse Concerning the Origine and Properties of Wind* (Oxford, 1671).

On the question of whether 'the waters' (i.e., those bodies of water large enough to move regularly in accord with the rest of the cosmos) move in an westerly direction, Bacon argues that they do. Their motion is slower than the similar motion of the air, we are told, but it is more apparent because of the relative density of water, which makes its effects more manifest (vi.78/79). He offers a number of observations in support of this westerly motion. He notes, for example, the westerly flow of water from the Indian Ocean into the Atlantic, this being the only unimpeded flow of large bodies of water: Where the flow is impeded, as it is by the New and Old Worlds, we find something different, but nonindicative of the general cosmic motion. He goes on to offer a second kind of argument for the westerly motion, which rests upon the verticity of the Earth, that is, the tendency manifested in magnetic needles to turn towards the vertex or pole (vi.84-6/83-5). Here he employs Gilbert's discovery of verticity, although their accounts differ in a number of respects.⁶⁶ For Gilbert, verticity occurs because the Earth is intrinsically magnetic, and it was on this basis that he proceeded to argue for the axial rotation of the Earth. The Earth's crust was corrupted, however, with the result that, while bodies at the core manifested a magnetic orientation from the equator in both directions north and south to the poles, so that polarity and alignment coincided, bodies made from the crust had a geographical alignment which was opposite to their polarity. Bacon, by contrast, rejects the theory of the Earth's magnetism, and while accepting a distinction between the unchanging state of the Earth's core and the mutability of its crust,⁶⁷ he accounts for verticity in a completely different way. The core itself is completely inactive, in Bacon's account, in contrast to the rotational motion of the heavens; but the matter making up the crust of the Earth rotates with the heavens, as the air and waters do, that is, it does not 'revolve on the poles'. Nevertheless, the encrustations or concretions of the Earth seem to act 'in consent with the revolutions of the heaven' in that 'they steer and turn themselves towards poles' (vi.84-6/85-7). The reason for this is as follows:

Since in every spinning orb which turns on fixed poles and has no motion of the centre there is a certain sharing in both a mobile and a fixed nature, when the power of revolving is bound up by the consistent or self-determining nature of the body, this virtue and appetite of self-direction nevertheless remains and is intensified and concentrated; with the result that direction and verticity towards poles in rigid bodies is the same thing as spinning on poles in fluid ones. (*Flux: BW* vi.86/87)

Finally, on the third question, that of how and from where the 'six-hourly reciprocation of tides arise', Bacon asks us to begin by imagining

66 See Rees, 'Francis Bacon on Verticity'.

67 Both Gilbert and Bacon may have got this doctrine from Telesio. See *ibid.*

the whole surface of the Earth being covered with water (vi.86/87). In this case, the water, being unobstructed in its flow, would continually move from east to west. Assume next that dry land consists in a single land mass stretching from north to south, so that its shape obstructs the westerly flow. In this case, the waters would eventually be driven back: There would be a flood tide followed by an ebb, every twelve hours. Finally, imagine a situation which Bacon considers effectively corresponds to the actual situation: The dry land is divided into two such land masses, the New World and the Old World, and that between these flow an ocean that is open only at the poles. These land masses would then 'communicate and insinuate the nature of a double reciprocation to the whole mass of waters, and from this arises that quarter of the diurnal motion; as, that is, with the waters checked on both sides, the ebb and the flow of the sea unfolds twice a day over a six-hour period, since there is a double advance and likewise a double retreat' (vi.86/87).

The works of 1611–12 hold the key to Bacon's matter theory and cosmology, establishing a quadripartite cosmos characterised by different forms of two basic kinds of matter – sulphur and mercury – at the subterranean, terrestrial, sublunar, and planetary/stellar regions. The nature of the matter in each region, together with the wholesale diurnal cosmic westerly movement, in which the fixed stars and the winds and tides share equally, provides the basic explanation for the physical behaviour of the universe. Reconciling this model with the observed phenomena is not so straightforward, yet Bacon has recourse only to relatively simple devices. At the celestial level, he relies upon the notion of a retardation of celestial bodies as one moves in from the periphery of the cosmos, and their increasing tendency to move in larger spirals as we approach the Earth, to account for various observed phenomena such as retrograde motions and systematic variations in brightness, in a qualitative if not a quantitatively satisfying way. At the terrestrial level, he relies on the obstruction to natural motion caused by various factors which can be taken into account fully in terms of the arrangement of matter: the squeezing of water through narrow channels in the case of tides, for example. Although most of the system is left in a very schematic and sketchy form, we have enough material on the fundamental issues to get a good sense of the essentials of a Baconian cosmology, and some of its detail. So far as I can tell, Bacon's is the last significant defence of a geocentric cosmology outside Jesuit circles,⁶⁸ and it is the last

68 The Jesuit natural philosopher Giambattista Riccioli set out a geoheliocentric system in his *Almagestum Novum* (Bologna, 1651), and this was being discussed seriously by fellow Jesuits into the 1670s. See Christine Schofield, 'The Tychonic and Semi-Tychonic World Systems', in René Taton and Curtis Wilson, eds., *Planetary Astronomy from the Renaissance to the Rise of Astrophysics, Part A: Tycho Brahe to Newton* (Cambridge, 1989), 33–44, at 38–40.

to pursue cosmology primarily as part of matter theory, without regard to the fine details of astronomical observation.

Spiritus and the preservation of life

Bacon's matter theory underlies not just a cosmology but also an account of plant and animal physiology. Moreover, not only is the dividing line between the inorganic and the organic not at all sharp in Bacon – in the tradition of the Renaissance naturalists, he sees matter as an essentially active realm, endowed with powers and forces that ease the transition from the nonliving to the living, and indeed from the nonsentient to the sentient – but the natural-philosophical underpinnings that Bacon has provided for the organic harbours the possibility of a spectacular practical outcome: the prolongation of life in plants and animals, and above all, in humans. We have already looked at how Bacon envisages this project, but not yet at its natural-philosophical underpinnings. These turn on his notion of *spiritus*, the only sustained general discussion of which occurs in *Sylva Sylvarum*.

In the last 'century' of *Sylva Sylvarum*, Bacon provides a detailed account of spirits, which brings out his naturalistic approach to the question. He begins with an attack on the Neoplatonic notion of a *spiritus mundi*. This was something which was postulated to pervade the universe but was not identified with God, and was thought by some – Bacon mentions Paracelsus – to allow a bridge with human spirit, a connection established by the force of the imagination. Bacon does not rule out the existence of 'immaterial virtues', but wants the investigation of such things to be put on a proper footing (*Sylva* X [Introductory ¶]: *Works* ii.640–1).⁶⁹ The activity of these 'immaterial virtues' has been rejected too easily, he tells us, just on the grounds that it sometimes fails; but just as infection and contagion pass from body to body and are received by passive bodies, yet do not always take hold because of the strength and good disposition of the body, so impressions passed from mind to mind, or spirit to spirit, are genuinely transferred, though the impression is 'encountered and overcome by the mind and the spirit, which is passive, before it work any manifest effect'. So just because spirits are not always transmitted effectively does not mean that they are not transmitted at all. Conversely, the fact that they are sometimes transmitted effectively should not be grounds for credulousness with regard to them: Someone who carries a ring or seal, believing it will enable him to achieve something, may behave more persistently and industriously and gain his goal as a result, but the ring or seal has contributed nothing

69 Subsequent citations in this section to 'century' X of *Sylva Sylvarum* will be given parenthetically in the text by paragraph number and *Works* volume and page.

directly in this case. In this connection, we should not be credulous in believing the stories of witches, which they themselves believe but which are the products of their imagination, and we should note that they claim to achieve their effects by ointments, which, by 'stopping of the pores, shut in the vapours, and send them to the head extremely.' In other words, we are dealing here with hallucinations which, given the strength of the opiate ointments used, have a physiological explanation (§§901–3: *Works* ii.641–3).

This reinforces the need for a proper systematic account of the 'transmission of spirits and imagination'. All spirits are transmitted by action at a distance rather than by contact, but there are eight distinct kinds of transmission. The first is the transmission or emission of the more airy parts of bodies, as in odours and infections (§§904: *Works* ii.643).⁷⁰ The second is the transmission or emission of 'spiritual species', namely 'visibles and sounds', which require a well-disposed medium and can easily be stopped (§§905: *Works* ii.643–4); these are also incorporeal, work swiftly, are effective at large distances, come 'in curious varieties', neither cause anything nor leave anything behind them but are merely 'energies', and finally are 'of so tender and weak a nature, as they affect only such a rare and attenuate substance as is the spirit of living creatures' (§§938: *Works* ii.651–2). Third, there are emissions which cause attraction of certain bodies at a distance, such as magnetism. Fourth, there is 'the emission of spirits, and immateriate powers and virtues, in those things which work by the universal configuration and sympathy of the world', such as gravity, the cosmic rotation from east to west, and tides (§§907: *Works* ii.644).

The fifth transmission type is 'the operation of the spirits of the mind of man upon other spirits', which we find in the case of the operations of vehement affections, as well as in that of strong imagination (§§908: *Works* ii.644). The affections make the spirits more powerful and active, Bacon observes, 'especially those affections which draw the spirits into the eyes' such as love and envy; he also mentions fear and shame in this connection. Any influence here works by means of spirit, however, 'and not by the eye alone.' At this point Bacon introduces a discussion of imagination, identifying its threefold power:

the first upon the power of the imaginant, including likewise the child in the mother's womb; the second is, the power of it upon dead bodies, as plants, wood, stone, metal, &c.; the third is, the power of it upon the spirits of men and living creatures. ([passage between §§945 and §§946]: *Works* ii.654)

⁷⁰ Bacon offers a detailed discussion of this question, mainly on plagues and other infections, as well as poisonous odours, offering some advice on healthy air at 645–51.

The investigation of such questions by his inductive method is, Bacon admits, 'wonderful hard', and he confines his attention to the influence of the imagination upon spirits of men. The question is whether believing something strongly helps one directly – that is, not by making one more industrious or persistent – to achieve it, by means of 'a secret operation, or binding, or changing the spirit of another.' One cannot perform the relevant experiments upon oneself in these cases: They must be performed by others. This provides what Bacon refers to as authority, and such authority enables us to fortify our imagination. We can also fortify imagination by quickening and corroborating it (by using particular gestures, vestments, seals, etc.) or by refreshing it, with wax images, for example. Just where this somewhat abstruse account is leading becomes clear in his next paragraph. If the imagination does have power, it is unlikely that it is so

incorporeal and immateriate a virtue, as to work at great distances, or through all mediums, or upon all bodies, but that the distance must be competent, the medium not adverse, and the body apt and proportionate. Therefore if there be any operation upon bodies in absence of nature, it is like to be conveyed from man to man, as fame is; as if a witch by imagination should hurt any afar off, it cannot be naturally, but by working upon the spirit of some that cometh to the witch; and from that party upon the imagination of another; till it come to one that hath resort to the party intended; and so by him to the party intended himself. (§950: *Works* ii.657)

What we have here is a conservative, deflationary account of the action of spirits, although Bacon makes it clear that there are few or no experiments that could demonstrate the action of spirits conclusively.

The sixth type of transmission of spirits lies in 'the influxes of heavenly bodies, besides those two manifest ones, of heat and light' (§909: *Works* ii.644). Seventh, there are 'the operations of sympathy', whereby to induce courage, for example, a person might wear the heart or spur of a cock on his wrist (§910: *Works* ii.645).⁷¹ The eighth and last kind is

71 On the question of animals' virtues as models for human ones, see Peter Harrison, 'The Virtues of Animals in Seventeenth-Century Thought', *Journal of the History of Ideas* 59 (1998), 463–84. Bacon's view is that there are many things that can work upon our spirits by means of secret sympathy and antipathy: 'the virtues of precious stones', for example, have generally been recognised, from antiquity onwards, to affect our spirits, and Bacon agrees that they do in fact contain fine spirits, 'as appeareth by their splendour', and 'therefore they may work by consent upon the spirits of man, to comfort and exhilarate them' (*Sylva* X §960: *Works* ii.660–1). If this is taken as a purely physical process, Bacon's treatment seems somewhat credulous, and at odds with his own earlier criticism, in his summary of *Historia Sympathiæ et Antipathiæ Rerum*, of the practitioners of natural magic, who, he told us there, 'in their folly expect to become acquainted with [nature's] outward face and mask, and by

‘the emission of immateriate virtues’, in which parts of something once whole but now separated will transmit virtue to one another (§911: *Works* ii.645).⁷²

There are a number of points at which Bacon’s discussion of the nature of *spiritus* mixes physiological considerations and cosmological ones. In *De Vijs Mortis*, he tells us that every body has *spiritus* ‘intermingled and enclosed within itself’, and this is by virtue of ‘the continual refining and concocting influence of the Sun and heavenly bodies.’ *Spiritus* is neither a power nor energy – this seems to be a direct denial of Aristotelian conceptions – but ‘a tenuous body distributed and invested in the grosser parts of things’ (*De Vijs: BW* vi.318/319).⁷³ In other words, it is material, as it was for Telesio. Moreover, the dissolution of things depends wholly on this tenuous body, for the gross parts of matter making up a body would stay intact were it not for the action of *spiritus*. It is *spiritus* that rules the terrestrial orb, and the revolution or cycle which brings things to their destruction. *Spiritus* can interact with gross matter in three way: First, it can be mixed with it, and we find this kind of *spiritus* in inanimate things, as well as in the tangible parts of living things; second, it can branch, acting through ‘slender passages and tiny channels’, and this kind of *spiritus* is to be found in the vegetable realm, and finally, it can be concentrated in small ‘cells’ or ‘storerooms’ (*cellulatos*), as in the case of animals.

external resemblances to detect internal properties’ (*Aditus: Works* ii.81/v.203–4). But there may well be a psychological dimension to the discussion. The effect of precious stones is to be attributed at least partly to their ability to reflect and intensify light, which ‘excelleth in comforting the spirits of man’ (*Sylva X* §960: *Works* ii.661), and the effect can be created with prisms and crystal just as much as with precious stones. Generally speaking, the spirits can be comforted by the wearing of bracelets of three kinds: refrigerant bracelets, such as those made of pearl or coral; corroborant bracelets, such as those made of bead-amber, hartshorn, or ivory; and aperient bracelets, such as those made of roots of *carduus benedictus*. Various others things that might be worn for the preservation of health, from the tying of periwinkle herb around the calf, to the tying of the guts of a wolf around the stomach, are reported, often with evident reservation although never with any account of a testing of the evidence. He reports various sympathies and antipathies between those who are blood-related, friends, and enemies, although his tone is occasionally apologetic, as when he tells us that ‘the sympathy of individuals, that have been entire, or have touched, is of all others the most incredible; yet according unto our faithful manner of examination of nature, we will make some little mention of it’ (*Sylva X* §997: *Works* ii.669).

72 Bacon has some doubts about these phenomena but refuses to rule them out of court.

73 Subsequent citations in this section to *De Vijs Mortis* will be given parenthetically in the text only by *BW* volume and page.

Spiritus is, then, very broad, and although its foundational standing is never clarified or spelled out in a satisfactory way, it is not something restricted to the animate realm. Nevertheless, it plays a limited role in Bacon's discussion of inanimate processes, and it is in the realm of the organic that the notion becomes indispensable.

Rejecting the assumptions on which previous accounts of aging have been based – such as that there must be some 'radical and primigenial humour', which gradually diminishes and cannot be replenished as we grow older, and which gradually becomes wholly consumed, at which point death results; or Telesio's account, whereby the body's heat increases with age, with the result that the liver becomes parched, and the blood, which depends on the liver, can no longer refresh the body properly (vi.270/271) – Bacon proposes in *De Vijs* to start afresh. The first step, he argues, must be to start by considering the animal as an inanimate thing, and once one has done that, only then move to considering it as something animate, by which he means something that nourishes itself. The rationale behind this is that inanimate and animate bodies suffer from the ravages of time in various ways, but animate bodies respond in a distinctive way to these ravages: Primarily through nourishment, they can repair injuries inflicted. This leaves us with three forms of inquiry: First, we consider animals purely as physical objects and investigate how they are corrupted or decayed by natural processes; second, we ask the same question of the animal now considered as animate; third, we look at how such animate entities can repair and make good any processes that would tend to corrupt the fabric of their bodies (vi.274/275).

As regards the corruption or decay of inorganic bodies, we can distinguish three stages: 'attenuation, and thereupon escape of the part attenuated, and contraction of the unattenuated part left behind' (vi.274/275). Attenuation is manifest in the fact of the gradual loss of weight in the body, but Bacon does not treat this simply as a loss of 'grosser substance'. The problem is that, in the corruption – or decay, or rusting, or wearing down – of inorganic bodies, or of organic bodies considered as inorganic, the matter that escapes does not simply fall off the body but is removed gradually and invisibly. All we notice is a gradual loss of weight, which suggests it is lost in the form of a vapour to which solid matter has become attached, so that the body cracks and dries and ultimately turns to dust.

Traditional accounts, Bacon complains, pass over these details and simply talk of desiccation and corruption, leading their proponents to search 'for empty remedies to do with moisturising and rekindling, and other worthless stories' (vi.278/279). If we are to discover 'where and how art can meet nature', we must first investigate 'the paths and en-

trances of nature' thoroughly. This requires us to discover how the processes described vary from thing to thing, 'and by what means these actions may be stimulated, contained, incited or abated.' Once we know this, we can begin to think in practical terms about the conservation of bodies. We must distinguish, however, between those processes wherein the dissolution of the body comes about through time, and those which involve putrefaction, which 'anticipates and forestalls natural dissolution and is the same thing in inanimate bodies as death from disease is in living ones' (vi.280/281).

The various 'actions' by which bodies decay or corrupt depend on three things: the type of *spiritus* enclosed in the body, the ways in which the gross matter encloses this *spiritus*, and the different external or ambient influences that affect the body from outside (vi.282/283). As regards the first question, Bacon tells us that some bodies shut in and conceal *spiritus*, and this *spiritus* can have two origins: Either it is a remnant of a living body, or it derives from fire. Under the first case fall corpses of animals, their excrement, and deracinated plants, but also metals and fossil matter removed from their ores, and substances that have been refined and separated. Under the second case fall glass, fired bricks, salts, and anything formed by fire out of a softer body (vi.284/285).⁷⁴ As for the second question, that of the ways in which gross matter encloses this *spiritus*, this gross matter can either ease or hinder the attenuation and escape of *spiritus*. When the matter enclosing it is similar to the *spiritus* itself, or when it is porous, this will usually ease attenuation; but when the surrounding matter is very different in nature from the *spiritus*, or when it is sticky or closely packed, it will hinder it (vi.284/285).⁷⁵ Finally, on the third question, ambient influences, there is a reciprocal action between these on the one hand and the *spiritus* and the gross matter on the other, introducing much more complexity into the process: They can open up or contract the gross matter, they can dissolve in and combine with *spiritus*, and so on (vi.284-6/285-7). Indeed, Bacon seems to consider the action of ambient conditions as primary ones for examination if our aim is the dissolution of inanimate bodies, for 'in inanimate bodies nothing can be taken or served up by mouth or internal organs in the way that it can in animals' (vi.286/287).

74 From among the various differences in *spiritus*, Bacon picks out two as being of particular importance: differences in bulk or in force, which depend either on the nature of the thing or upon how much time has elapsed since the death of a thing; and differences in concentration and distribution of *spiritus*.

75 Bacon begins to sketch out other effects of the surrounding matter, but tells us he will leave these questions for another time.

Bacon moves next to 'lay bare the appetities and desires of nature' (vi.286/287), identifying three characteristic things that *spiritus* does:

The first is to exercise and enjoy its own nature by motion and agitation; for it is implicit in the nature of all rare substances that they are impatient of complete passivity, especially when they are imprisoned and find themselves among hostile bodies. The second is to multiply themselves and feed off other things, according to the resources available, in order to preserve and increase themselves thereby. The third is to escape and draw near to kindred and connatural substances, and to unite themselves with them. (vi.286–8/287–9)

It is from these sources, Bacon tells us, that these actions of attenuation and escape proceed, although he does not provide details, preferring instead to elucidate various discrete features of *spiritus* as it bears on organic processes and remedial measures. Many of these focus on plant physiology, an area in which Bacon provides much practical detail and advice elsewhere,⁷⁶ and there is a significant degree of extrapolation from plant to animal physiology in his account of the prevention of ageing processes, although there is also a central contrast between the nutritive and repair processes in plants and animals. So, for example, Bacon tells us that extrinsic spirits are produced in vegetable bodies from newly deposited dew and rain, and they make the body swell but dilute its powers, something that can be prevented by exposing such bodies to the air as soon as they have been picked, and storing them 'in a cool, shady place where the sun's rays cannot disturb the inner spirits.' Intrinsic spirits, on the other hand, enter the body through feeding, and this is

⁷⁶ The fifth, sixth, and much of the seventh 'centuries' of *Sylva Sylvarum*, for example, deal with plants (*Works* ii.475–550), and while the treatment is derivative – Pliny, della Porta, and (indirectly) Theophrastus are the main sources – there is a good deal of practical detail. The topics covered include acceleration and retardation of germination; the melioration of fruits, trees, and plants generally; the mixing of different plant species; the sympathy and antipathy of plants; making medicine out of plants; curiosities concerning fruits and plants; the degeneration of plants and their transmutation into one another; the artificial dwarfing of trees; the excrescences of plants; the production of perfect plants without seeds; foreign plants; the seasons in which plants blossom and seed; the longevity of herbs and trees; the shapes of plants; the principal differences between plants; composts; the affinities and differences between plants and inanimate bodies, and between plants and living creatures. Bacon's work on botany was taken up in a number of authors, e.g., R. Austin, *Observations upon some part of Sr Francis Bacon's Naturall History as it concerns Fruit-trees, Fruits, and Flowers* (Oxford 1658), expanded in his *A Treatise of Fruit-Trees* (Oxford, 1665), to which the *Observations* were appended; also, and more important, in John Evelyn, *Sylva; or, A Discourse of Forest-Trees, and the Propagation of Timber in His Majesties Dominions* (London, 1664).

a more complex process in which they are removed by excretion and sweating (vi.290–2/291–2).⁷⁷

In some cases, inanimate, plant, and animal bodies can be compared in terms of the action of *spiritus*. So, for example, we are told that ‘the more finely divided the spirit in a body, the more durable the body turns out to be’ (vi.294–8/295–9). A contrast is drawn between several different kinds of materials here. In metals the *spiritus* is so broken up and dispersed that the grosser parts completely swamp their action, with the result that time has little effect on their dissolution unless they are heated so that the grosser parts are opened up. *Spiritus* is also finely dispersed in gums, which are similarly long-lasting, but the case is quite different from that of metals: The grosser parts of gums, far from breaking up *spiritus*, as the grosser parts of metals do, have a ‘docility and stickiness’ which causes them to adhere to the *spiritus*. Oils and fats work on the same principle. The practical lesson to be drawn is that, in animals, exercise promotes longevity because it makes the body compact and cramps the *spiritus*. Cold and medicines work in the same way. Similarly, if the *spiritus* is unevenly distributed in the body, its dissolution will be hastened (vi.298–300/299–301). *Spiritus* is most active where it is most concentrated, for it strives forcefully to join up with the *spiritus* nearest to it, and this is the cause of the dissolution of the thing. Most natural things, including metals in ore form, have unevenly distributed spirits, but those subjected to fire develop a more even distribution. This is true of metals, ceramics, and even of roasted meats. In the case of animals, a more even distribution of *spiritus* can be induced by ‘gentle agitation, moderate massaging, simplicity of diet and food, and mildness of climate.’⁷⁸

In spite of the fact that the discussion leaves many questions unanswered, what *De Vijs* does make clear is the extent to which *spiritus* acts to bind together cosmology and biology, unifying Bacon’s matter theory. We can also begin to see just how a natural philosophy that rests almost

77 The first aphorism is labelled ‘Aphorism 5’: the aphorisms are not labelled sequentially and their organisation is somewhat chaotic as far as numbering goes, reflecting the provisional nature of the manuscripts and the extensive revisions.

78 Among other practical remedies for aging, Bacon explains that if the *spiritus* cannot escape from the body, it acts on the grosser parts and turns them into a liquid, which it can move more easily: Indeed, this is just a step on the way to converting the matter into *spiritus*. Retention of *spiritus* in the body is the essence of conservation in liquids, which must be kept in sealed bottles, as much as in solids, which can be conserved if they are sealed in some way. In the case of the human body, Bacon remarks that there is greater longevity in those cultures in which bodies are painted (ancient Britons, Central American Indians, Virginian Indians, and Brazilians) (*De Vijs*: BW vi.304–10/305–11).

exclusively on matter theory might function, in cosmology as well as in plant and animal physiology, even though, in the latter cases, it is clear that the matter theory – in the form of *spiritus* theory – is doing little independent work, but rather is brought in to provide a rationale for reports, observations, and remedies which otherwise show no underlying unifying principles.

How far we can see this as a test of Bacon's 'method' is very difficult to determine. It is, for example, inescapably clear that there is quite a significant difference between those writings designed for the third part of the 'Great Instauration' and *Sylva Sylvarum*, and, at least from the point of view of the assessment of the 'Great Instauration', it is unhelpful to include the bulimic *Sylva Sylvarum*, which presents undigested raw materials, by contrast with the histories of the winds, or rarity and density, for example, where the material is sifted with some care and subjected to scrutiny. The 'histories' indicate that Bacon had the methodological and other resources to make genuine advances, although it is difficult to gauge just how far he would have been able to proceed towards the fourth and fifth parts of the 'Great Instauration', where the aim is to supply concrete examples for guidance and to build up a provisional body of theory. For this, there is no doubt that he would have needed the kinds of resources for which he had petitioned James I and others – resources which, as we saw in Chapter 5, he never really thought through.

Conclusion

Charles Webster has noted that, unlike Descartes, Bacon wrote nothing that could be translated into textbook form;¹ but Bacon's contribution was not really the kind of thing that could have been encapsulated in such a form. Even his account of inductive procedures is so geared to the particular problems faced in pursuing the matter theory of his time that, although some insights are undeniably generalisable, unlike the theories of method of nineteenth- and twentieth-century philosophy of science the attractiveness of his account lies primarily in the attention to detailed problems facing the isolation of particular properties of matter, a detail which was gradually superseded as the discipline became transformed and its role in physical inquiry rethought. Bacon's main contribution is not one to be described as lasting so much as irreversible. He inaugurated the transformation of philosophy into science, and philosophers into scientists, for even though the ideas of 'science' and 'scientists' in the modern sense are only really established in the nineteenth century, their genealogy goes back to Bacon's attempt to effect a fundamental reform of philosophy from a contemplative discipline exemplified in the individual persona of the moral philosopher, to a communal, if ultimately centrally directed, enterprise exemplified in the persona of the experimental natural philosopher. In turn, observation and experiment are lifted out of the purview of the arcane and the esoteric, and planted firmly in the public realm. It is this that ultimately is one of the key developments that enables the transformation of scientific activity from an enterprise that had traditionally exhibited a pattern of slow, irregular, intermittent growth which alternates with substantial periods of stagnation, into the uninterrupted and cumulative growth that constitutes the general rule for scientific development in the West since then.²

1 Charles Webster, *The Great Instauration: Science, Medicine and Reform (1626–1660)* (London, 1975), 108.

2 On these questions see Joseph Ben-David, *The Scientist's Role in Society: A Comparative Study* (Chicago, 1984).

Bacon's reshaping and defence of natural philosophy, his establishment of its autonomy, legitimacy, and central cultural role, are, I believe, on a par with Plato's defence of the autonomy and centrality of the 'quiet' virtues, such as justice and moderation. Both shaped the cultures in which they lived, and shaped them irreversibly, moulding those which followed, above all our own.

Bacon was, of course, not the only influential figure to have called for a fresh start: Bruno, Campanella, Descartes, Gassendi, and others were doing so as well. Of these, only Descartes's proposal for a new start was to have the same longevity as Bacon's; but the two calls were motivated very differently. Descartes really had something very different to offer – in mathematics, in geometrical and physical optics, in cosmology, in physiology, in the understanding of cognition and the mind – and his call for a fresh start, at least in the general metaphysical version we find in the *Meditations*, is as much as anything else a way of getting a hearing for his radical offerings, a way of showing that if we follow the procedure of starting from indubitable foundations, we will be led to his substantive natural-philosophical doctrines.³ In terms of substantive doctrine, Bacon does not really have a great deal to offer, and what he does propose – his defence of a geocentric cosmology and his account of *spiritus*, for example – is quickly superseded. There are no Baconians on points of substantive natural-philosophical doctrine, as there were Cartesians on points of substantive doctrine, such as the theory of vortices and a mechanistic physiology.

Rather, to be a Baconian meant to accept Bacon's understanding of the role and place of natural philosophy, and to adopt his distinctive means of achieving results in natural philosophy. In this latter respect, Bacon's starting point was more attractive and compelling than that of Descartes: It offered less, but it was also less contentious. Although Descartes's general idea of the need for knowledge to be grounded in some basic metaphysical/epistemological theory attracted many advocates throughout the seventeenth and eighteenth centuries, none of his successors accepted hyperbolic doubt as a rationale for building up knowledge afresh, and so none adhered to any of the specifics of his programme. The situation with Bacon is very different. Bacon's reasons for starting afresh are real and compelling, and not speculative in the sense that Descartes's are. As we have seen, Bacon's account of the Idols allows him to make the case for a new start in a particularly compelling way. The doctrine of Idols sets out to show that we pursue natural philosophy with seriously deficient natural faculties, that we operate with

3 See my *Descartes, an Intellectual Biography* (Oxford, 1995).

a severely inadequate means of communication, and that we rely on a hopelessly corrupt philosophical culture: claims much more radical than anything we find in Descartes. The deficiencies of our faculties are not due to their inability to deal with a purely speculative form of doubt, but, quite the contrary, are wholly real and in constant evidence in our daily lives.

Bacon's account of the Idols, set out in detail only in the 1620s, could not have failed to strike a chord with his readers, and the general thrust, if not the details, of his advocacy of a new way of pursuing natural philosophy began finally to gain wide recognition. Immediately after his death, his work was taken up by a number of different movements in England, from the radical Puritans to the founders of the Royal Society. These movements shared a common concern: Bacon's emphasis on the communal nature of natural-philosophical investigation, and with it replacement of adversarial argument with a form of experimental 'witnessing'. Indeed, this was to be the first theme which his English followers picked out after his death; but it was nurtured in a different environment from that in which it had been proposed. The social and cultural life of England was very different in the period after the English Civil War from that of Tudor and early Stuart England, and many of Bacon's proposals for the reform of natural philosophy were less appropriate in the Restoration, for example, than they had been under James I. In particular, as we have seen, Bacon always had a centrally directed model in mind. Natural philosophy was *opera basilica* – works for a king – and not something that a private individual or group could undertake.⁴ Not only that, but research and teaching of natural philosophy in universities and elsewhere must be supervised, not by those who had already made a contribution to the area, or by those in the vanguard of natural philosophy research, but by 'princes or superior persons of visitation'.⁵

Such a hierarchical conception could have little purchase in post-Civil War England. There, the nonadversarial approach to natural philosophy, with its replacement of argument with experiment, flourished. What seems to have happened in Restoration England is that a number of considerations bearing on experimental practice and the behaviour of experimental practitioners, considerations which Bacon had begun to articulate, suddenly seemed to provide the answer to a profound sectarian strife and uncertainty about the nature of authority. It should be noted here that the issue of adversarial argument was not confined to natural philosophy, and can be found, for example, in connection with

4 *Adv. Learn. II: Works* iii.328.

5 *Ibid.: Works* iii.326.

religious debates;⁶ moreover, the issue of a 'civil' and experimental approach to natural philosophy, and the inculcation of these values in natural philosophers, was not exclusive to England.⁷ Nevertheless, a peculiar conjunction of circumstances in Restoration England, which made questions of social stability and authority paramount in virtually every sphere of life, produced a pervasive ideology of a gentlemanly, 'experimental' form of life in which dispute could occur safely, and agreement could be reached by means of a collective or shared witnessing of experiments, thereby providing a form of legitimation that guided natural-philosophical practice in a number of ways.⁸

The role of experiment changes radically at the beginning of the eighteenth century however, especially during Desaguliers's tenure of the position of Curator of Experiments in the Royal Society, from 1714 to 1744. Here we witness a shift to a view of experiment as something that

6 Thomas White, *Controversy Logicke; or, The Methode to come to truth in debates of Religion* ([Paris], 1659), 11–12, states his aim as being

to shew, that a quietnesse and solitude; in which, our braine is serene, and our spirits are calme, and a man hath his best wittes present to him: Not, publicke disputes, wherein vsually, is nothing but wrangling, and provoking one another into distempers and mutuall animosities: Is the most proper meanes to discern truth, and especially in matters of Religion.

7 It had, for example, been raised by Descartes in his *La Recherche de la Vérité par la lumière naturelle*, which dates from the 1630s or 1640s (*Oeuvres de Descartes*, ed. Charles Adam and Paul Tannery, 11 vols. [2d ed., Paris, 1974–86], x.495–527). See the discussion in Alberto Guillermo Ranea, 'A "Science for honnêtes hommes": *La Recherche de la Vérité* and the Deconstruction of Experimental Knowledge', in Stephen Gaukroger, John Schuster, and John Sutton, eds., *Descartes' Natural Philosophy* (London, 2000), 313–29. More generally, see Lorraine Daston, 'Baconian Facts, Academic Civility, and the Prehistory of Objectivity', in Alan Megill, ed., *Rethinking Objectivity* (Durham, N.C., 1994), 37–63, at 52ff.

8 Steven Shapin and Simon Schaffer, *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, 1985), and Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth Century England* (Chicago, 1994), look at this question in detail. They bring to light an important and hitherto neglected aspect of Restoration natural philosophy, although they give the impression that it is constitutive of Boyle's programme of natural philosophy, for which I can find no grounds. They are surely right, however, to see the pervasive ideology of a gentlemanly, 'experimental' form of life as something that pervades and in some respects shapes natural-philosophical practice. Less important (to my mind at least), they treat the phenomenon as if it were peculiar to English natural philosophy, which it was not, as we have just seen, and they do not trace its origins back further than Boyle, whereas we have also seen that there are significant Baconian precedents for both the idea of a via media and for the idea of experiment and observation replacing Scholastic methods of disputation.

demonstrates the public usefulness of knowledge,⁹ in many respects something extrinsic to how one actually produces results in natural philosophy, and so no more authentically 'Baconian' than the ideology of 'collective witnessing', although both clearly have Baconian precedents.

Nevertheless, it may seem surprising that Bacon's successors in the seventeenth and eighteenth centuries should have derived particular inspiration from him in the one area in which he is weakest: in setting out what is needed for the large-scale reform of natural philosophy into an organised communal enterprise.¹⁰ Yet although he may have had no idea of how to implement a solution, Bacon not only posed the problem in a stark and challenging way, but offered a model of scientific investigation that depended not on individual scholarship but on routinised methods of investigation which anyone could be trained to follow. Bacon began the transformation of the philosopher into what, in the nineteenth century, would become the scientist, someone who would increasingly – even in the course of the seventeenth century – be seen as concerned with factual rather than speculative issues. The philosopher becomes transformed in the process. As Locke puts it in a famous passage in the 'Epistle to the Reader' at the beginning of *An Essay concerning Human Understanding*:

The Commonwealth of Learning is not at this time without Master-Builders, whose mighty Designs, in advancing the Sciences, will leave lasting monuments to the Admiration of Posterity: But every one must not hope to be a Boyle, or a Sydenham; and in an Age that produces such Masters, as the Great Huygenius, and the Incomparable Mr. Newton, with some other of that strain; 'tis Ambition enough to be employ'd as an Under-Labourer in clearing Ground a little, and removing some of the Rubbish that lies in the Way to Knowledge.¹¹

The view of the reformed natural philosopher/scientist as the master builder and the philosopher as underlabourer was not universal. The great tradition of German systematic metaphysics from Leibniz to Kant was very much one of Scholastic philosophy radically reformed and renewed, and even British empiricism had its system builder in Berke-

9 See Larry Stewart, *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660–1750* (Cambridge, 1992).

10 Note, for example, Glanville's remarkable claim in the 'Adress to the Royal Society' which opens his *Scepsis Scientifica*, that 'Solomon's House in the NEW ATLANTIS was a Prophetick Scheme of the Royal Society': *Scepsis Scientifica; or, Confest Ignorance, the way to science* (London, 1665), sig. c1^v.

11 *The Works of John Locke Esq.*, 2d ed., 3 vols. (London, 1722), i.ix.

ley:¹² no underlabourers there. Still, the notion that the only systems were scientific ones, and that system building was not the business of philosophers, did predominate in Britain, Hume being its most able defender, and in France, largely through the influence of Voltaire. The result was that, to a large extent, cognitive values came to be shaped around scientific values. This had major cultural implications: with the rise to predominance of scientific and technological measures of human capacity during the industrial era, for example, where Western Europeans considered their superiority to lie shifted – in a disconcertingly seamless way – from their religion to their science.¹³ And the export of Western science and technology, and the cognitive values associated with these, began.

Philosophy was, of course, not immune to these upheavals. It was torn apart as it gave birth to a scientific culture, and as one of the defining characteristics of modernity, the divide between the sciences and the humanities, emerged. The division did not come about by chance, nor was it a kind of oversight. It was engineered as part of the conditions of possibility of the emergence of a scientific culture – and its first engineer was Bacon.

12 See George Berkeley, *A Chain of Philosophical Reflections and Inquiries concerning the Virtues of Tar Water; and divers other subjects connected together from one another* (London, 1744: 2d ed. of the same year adding the main title *Siris*).

13 See Michael Adas, *Machines as the Measure of Man: Science, Technology, and Ideologies of Western Dominance* (Ithaca, N.Y., 1989).

Bibliography

Primary sources

- Acosta, José de, *The Natural and Moral History of the Indies*, trans. Edward Grimston (London, 1604).
- Agricola, Georgius, *De Re Metallica Libri XII* (Basel, 1556).
- Aldrovandi, Ulisse, *Ornithologiae, Hoc Est de Avibus Historiae*, 3 vols. (Bologna, 1599–1603) (*Ornithologiae, Hoc Est, de Avibus* [1599/1600]; *Ornithologiae Tomus Alter de Avibus* [1602]; *Ornithologiae Tomus Tertius* [1603]).
- Amico, Giovanni Battista, *De Motibus Corporum Caelestium iuxta Principia Peripatetica sine Eccentris et Epicyclis* (Venice, 1536).
- Andreæ, Johann Valentin, *Reipublicæ Christianopolitanæ Descriptio* (Strasbourg, 1619).
- Ascham, Roger, *English Works*, ed. William A. Wright (Cambridge, 1970).
- Ashmole, Elias, *Theatrum Chemicum Britannicum. Containing Severall Poeticall Pieces of our Famous English Philosophers, who have written the Hermetique Mysteries in their owne Ancient Language* (London, 1652).
- Austin, Ralph, *Observations upon some part of Sr Francis Bacon's Naturall History as it concerns Fruit-trees, Fruits, and Flowers* (Oxford, 1658).
- A Treatise of Fruit-Trees, Shewing the manner of Planting, Grafting, Pruning, and ordering them in all respects, according to the Rules of Experience* (Oxford, 1665).
- Aversa, Raphael, *Logica Institutionibus Præviis Quæstionibus Contexta* (Rome, 1623).
- Bacon, Francis, *The Works of Francis Bacon*, ed. James Spedding, Robert Leslie Ellis, and Douglas Denon Heath, 14 vols. (London, 1857–74; facsimile reprint, Stuttgart/Bad Cannstatt, 1989) [abbr. *Works*].
- The Oxford Francis Bacon*, gen. eds. Graham Rees and Lisa Jardine, projected 12 vols. (Oxford, 1996 onwards) [abbr. *BW*].
- See also Farrington, *The Philosophy of Francis Bacon* [abbr. *PFB*].
- Bacon, Roger, *Opus Maius*, ed. J. H. Bridges, 3 vols. (London, 1897–1900).
- Barlow, William, *The Navigator's Supply* (London, 1597).
- Berkeley, George, *Siris: A Chain of Philosophical Reflections and Inquiries concerning the Virtues of Tar Water; and divers other subjects connected together from one another* (London, 1744).
- Blagrove, John, *Astrologium Vranicum Generale* (London, 1596).
- Blith, Walter, *The English Improver; or A New Survey of Husbandry* (London, 1649).

- Blount, Thomas, *A Natural History: Containing Many not Common Observations: Extracted out of the best Modern Writers* (London, 1693).
- Blundeville, Thomas, *Exercises containing sixe Treatises, whiche treatises are verie necessary to be read and learned of all young gentlemen that haue not bene exercised in suche disciplines, and yet are desirous to haue knowledge as well in Cosmographie, Astronomie and Geographie, as also in the Arte of Navigation* (London, 1594).
- Bodin, Jean, *Universæ Naturæ Theatrum* (Frankfurt, 1597).
Oeuvres philosophiques, ed. Pierre Mesnard (Paris, 1951).
- Boethius of Dacia, *On the Supreme Good*, ed. and trans. J. F. Wippel (Toronto, 1987).
- Bowman, Thomas, *A Discourse Concerning the Origine and Properties of Wind* (Oxford, 1671).
- Boyle, Robert, *The Works of the Honourable Robert Boyle*, ed. T. Birch, 2d ed., 6 vols. (London, 1772).
- Brahe, Tycho, *De Mundi Ætherei Recentioribus Phænomenis* (Uraniburg, 1588).
- Brathwayt, Robert, *The English Gentleman* (London, 1630).
- Breton, Nicholas, *The Court and the Country* (London, 1618).
- Briggs, Henry, *Logrithmorum Chilias Prima* (London, 1617).
- Bruno, Giordano, *Spaccio de la Bestia Trionfante* (Paris, 1584).
The Expulsion of the Triumphant Beast, ed. and trans. Arthur D. Imerti (New Brunswick, 1964).
- Burton, Robert, *The Anatomy of Melancholy*, 2 vols. (1st ed., 1621; London, 1826).
- Cabero, Chrysostomus, *Brevis Summularum Recapitulatio* (Valladolid, 1623).
- Campanella, Tommaso, *Philosophia, Sensibus Demonstrata* (Naples, 1591).
Città del sole (Frankfurt, 1623).
- Cardano, Girolamo, *Practica Arithmetica Generalis* (Mediolani, 1539).
De Subtilitate Libri XXI (Nuremberg, 1550).
De Rerum Varietate Libri XVII (Basel, 1557).
Opera Omnia, 10 vols. (Leiden, 1663).
- Chaloner, Sir Thomas, *A short Discourse of the most rare Vertue of Nitre* (London, 1584).
- Charleton, Walter, *Physiologia Epicuro-Gassendo-Charltoniana; or, A Fabrick of Science Natural, upon the Hypothesis of Atoms* (London, 1654).
- Clavius, Christopher, *Modus quo Disciplinæ Mathematicæ in Scholis Societatis Posse Promoveri* (Rome, 1586).
- Cleland, James, *Hero-Paideia; or, The Instruction of a Young Nobleman* (Oxford, 1607).
- Conti, Natale, *Mythologiæ sive Explicationis Fabularum Libri X* (Venice, 1551).
- Cudworth, Ralph, *The True Intellectual System of the Universe*, 2 vols. (London, 1678).
- Dee, John, *Propædeumata Aphoristica* (London, 1558).
Monas Hieroglyphica (Antwerp, 1564).
The Elements of the Geometrie of the most auncient Philosopher Euclide of Megara, trans. Sir Henry Billingsley, ed. John Dee (London, 1570).
The Mathematicall Præface to the Elements of Geometrie of Euclid of Megara (1570), with an introduction by Allen G. Debus (New York, 1975).
Parallacticæ Commentationis Praxeosque Nucleus Quidam (London, 1573).

- Descartes, René, *Oeuvres de Descartes*, ed. Charles Adam and Paul Tannery, 2d ed., 11 vols. (Paris, 1974–86).
- Diderot, Denis, *Encyclopédie, ou Dictionnaire raisonné des sciences, des arts et des métiers*, 17 vols. (Paris, 1751–65).
- Digby, Everard, *De Duplici Methodo Libri Duo, Unicam P. Rami Methodum Refutantes* (London, 1580).
- Digby, Sir Kenelm, *Two Treatises, in one of which, The Nature of Bodies; in the other, The Nature of Mans Soule; is looked into: in way of discovery, of the Immortality of Reasonable Soules* (London, 1644).
- Digges, Leonard, *A Geometrical Practise, named Pantometria*, ed. Thomas Digges (London, 1571).
- Digges, Thomas, *Alæ seu Scalæ Mathematicæ* (London, 1573).
A Perfit Description of the Cælestiall Orbes according to the most aunciente doctrine of the Pythagoreans, lately reuised by Copernicus and by Geometricall Demonstrations approued, printed as an appendix to Leonard Digges, *A Prognostication euerlasting* . . . *Lately corrected and augmented by Thomas Digges* (London, 1576).
- Diogenes Lærtius, *Lives of Eminent Philosophers*, ed. and trans. R. D. Hicks, 2 vols. (Cambridge, Mass., 1925).
- Drake, Stillman, and Drabkin, I. E., *Mechanics in Sixteenth-Century Italy: Selections from Tartaglia, Benedetti, Guido Ubaldo, and Galileo* (Madison, 1969).
- Duchesne, Joseph, *Liber de Priscorum Philosophorum Veræ Medicinæ Materia Præparationis Modo* (Paris, 1603).
Ad Veritatem Hermeticæ Medicinæ ex Hippocratis Veterumque Decretis (Paris, 1604).
- Edmundes, Clement, *Observations upon Cæsars Commentaries* (London, 1609).
- Elyot, Sir Thomas, *The Boke Named The Governour* (London, 1531).
- Erasmus, Desiderius, *A Lytell Booke of Good Maners for Chyldren* (London, 1532).
The Erasmus Reader, ed. Erika Rummel (Toronto, 1990).
- Evelyn, John, *Sylva; or, A Discourse of Forest-Trees, and the Propagation of Timber in His Majesties Dominions* (London, 1664).
- Fiston, William, *The Schoole of Good Manners* (London, 1609).
- Fludd, Robert, *Utriusque Cosmi Maioris Scilicet et Minoris Metaphysica, Physica atque Technica Historia*, 2 vols. (Oppenheim/Frankfurt, 1617–21).
- Fracastoro, Girolamo, *Homocentrica: Sive de Stellis* (Venice, 1538).
- Frisius, Gemma, *Arithmetica Practicæ Methodus Facilis* (Antwerp, 1540).
- Galileo Galilei, *Two New Sciences*, trans. Stillman Drake (Madison, 1974).
- Gassendi, Petrus, *Opera Omnia*, 6 vols. (Lyon, 1658).
- Gesner, Conrad, *Historiæ Animalium*, 5 vols. (Zürich, 1551–87).
- Gilbert, Sir Humphrey, *Queene Elizabethes Academy*, ed. F. J. Furnivall for the Early English Text Society (London, 1869).
- Gilbert, William, *De Mundo Nostro Sublunari Philosophia Nova* (Amsterdam, 1651).
On the Magnet, trans. Silvanus P. Thompson (New York, 1958).
- Glanville, Joseph, *Scepsis Scientifica; or, Confest Ignorance, the way to science; In an Essay of The Vanity of Dogmatizing, and Confident Opinion* (London, 1665).
Scire/i Tuum Nihil Est; or, The Author's Defence of the Vanity of Dogmatizing; Against the Exceptions of The Learned Tho. Albius in his Late Sciri (London, 1665).

- Graves, George, *Naturalist's Pocket-Book or Tourist's Companion* (London, 1819).
- Greville, Fulke, *The Life of the Renowned Sr Philip Sidney* (London, 1652).
- Harvey, Gabriel, *The Letter Book of Gabriel Harvey A.D. 1573–1580*, ed. E. J. L. Scott (London, 1884).
- Harvey, William, *The Works of William Harvey*, trans. Robert Willis (London, 1847).
- Hill, Nicholas, *Philosophia Epicurea, Democritiana, Theophrastica proposita simplicitate non edocta* (Paris, 1601).
- Hobbes, Thomas, *The Correspondence*, ed. Noel Malcolm, 2 vols. (Oxford, 1994).
- Hoby, Sir Thomas, *The Courtyer* (London, 1561).
- Hooke, Robert, *Micrographia; or, Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses with Observations and Inquiries thereupon* (London, 1665).
- Hornius, Georg, *Historiæ Philosophicæ Libri Septem, Quibus de Origine, Successione, Sectis & Vita Philosophorum ab Orbe Conditio ad Nostram Ætatem Agitur* (Leiden, 1655).
- Huygens, Christiaan, *Oeuvres complètes de Christiaan Huygens*, ed. La Société Hollandaise des sciences, 22 vols. (The Hague, 1888–1950).
- La Popelinière, Henri, *Histoire des histoires, avec l'Idée de l'histoire accomplie* (Paris, 1599).
- Le Roy, Loys, *De la vicissitude ou variété des choses en l'univers, et concurrence des armes et des lettres par les premières et plus illustres nations du monde, depuis le temps où a commencé la civilité, et mémoire humaine jusques à présent* (1575), ed. Philippe Desan (Paris, 1988).
- Of the Interchangeable Course, or Variety of Things in the Whole World*, trans. Robert Ashley (London, 1594).
- Lipsius, Justus, *De Constantia* (Leiden, 1584).
- Sixte Books of Politickes or Civil Doctrine*, trans. William Jones (London, 1594).
- Manducationis ad Stoicam Philosophiam Libri Tres* (Antwerp, 1604).
- Locke, John, *The Works of John Locke Esq.*, 2d ed., 3 vols. (London, 1722).
- Long, A. A., and Sedley, D. N., *The Hellenistic Philosophers*, 2 vols. (Cambridge, 1987).
- Machiavelli, Niccolò, *The Prince*, trans. George Bull (London, 1970).
- Mandeville, Thomas, *A Treatise of the Hypochondriack and Hysterick Diseases* (London, 1730).
- Mersenne, Marin, *La Vérité des sciences* (Paris, 1625).
- Correspondance du P. Marin Mersenne, religieux minime*, ed. Cornelius de Waard, R. Pintard, B. Rochot, and A. Beaulieu, 17 vols. (Paris, 1932–88).
- More, Thomas, *A fruteful, and pleasaunt worke of the beste state of a publyque weale, and of the newe yle called Utopia*, trans. Raphe Robynson (London, 1555).
- Mulcaster, Richard, *Positions, wherein those primitive circumstances be examined, which are necessarie for the training up of children, either for skill in their booke, or health in their bodie* [1581], ed. Robert H. Quick (London, 1888).
- Napier, John, *Mirifici Logarithmorum Canonis Descriptio, ejusque usus . . .* (Edinburgh, 1614).
- De Arte Logistica*, ed. Mark Napier (Edinburgh, 1839).
- Nashe, Thomas, *Pierce Penilesse his supplication to the Deuill* (London, 1592).
- Norman, Robert, *The newe Attractiue, Containyng a short discourse of the Magnes or Lodestone, and amongst his other vertues, of a newe discovered secret and sub-*

- till proprietie, concernyng the Declinyng of the Needle, touched therewith vnder the plaine of the Horizon (London, 1581).
- Ogier, François, *Apologie pour Monsieur de Balzac* (Paris, 1628).
- Oughtred, William, *Clavis Mathematicæ* [1631] (London, 1648).
- Patrizi, Francesco, *Discussionum Peripateticarum Tomi Quattuor* (Basel, 1581).
- Nova de Vniuersis Philosophia* (Venice, 1593).
- Peacham, Henry, *The Compleat Gentleman* (London, 1622).
- Pereira, Benito, *De Communibus Omnium rerum Naturalium Principijs et Affectionibus Liber Quindecim* (Rome, 1576).
- Pomponazzi, Pietro, *Tractatus de immortalitate animæ* (Bologna, 1516).
- Porta, Giambattista della, *Magiæ Natvralis Libri Viginti in Qvibus Scientiarum Naturalium Diuitiæ Demonstratur* (Frankfurt, 1597).
- Priestley, Joseph, *Essay on Government* (London, 1768).
- Puttenham, George, *The Arte of English Poesie* (London, 1589).
- Ramus, Petrus, *Pro Philosophica Parisiensis Academiæ Disciplina* (Paris, 1551).
- Proœmium Mathematicum* (Paris, 1567).
- The Logike of the Most Excellent Philosopher P. Ramus Martyr* (London, 1574).
- Recorde, Robert, *The Castle of Knowledge* (London, 1556).
- Arithmetick; or, The Ground of Arts . . . augmented by John Dee, enlarged by John Mellis* (London, 1654).
- Reid, Thomas, *The Works of Thomas Reid*, ed. Sir William Hamilton, 2 vols. (London, 1863).
- Riccioli, Giambattista, *Almagestum Novum* (Bologna, 1651).
- Russell, Sir Thomas, *Diacatholicon Aureum* (London, 1602).
- Sanderson, Robert, *Logicæ Artis Compendium* (Oxford, 1615).
- Sandys, George, *A Relation of a Journey Begun An: Dom: 1610* (London, 1615).
- Sennert, Daniel, *De Chymicorum cum Aristotelicis et Galenicis Consensu ac Dissensu Liber 1* (Wittenberg, 1619).
- Hypomnemata Physica* (Frankfurt, 1636).
- Sidney, Sir Philip, *The Countess of Pembroke's Arcadia*, ed. Maurice Evans (Harmondsworth, 1977).
- An Apology for Poetry*, ed. Geoffrey Shepherd (London, 1965).
- Spedding, James, ed., *Bacon: A Conference of Pleasure* (London, 1870).
- Sprat, Thomas, *The History of the Royal-Society of London for the Improving of Natural Knowledge* (London, 1667).
- Stanley, Thomas, *The History of Philosophy: containing the Lives, Opinions, Actions and Discourses of the Philosophers of every Sect*, 2d ed., 3 vols. (London, 1687).
- Starkey, Thomas, *A Dialogue between Reginald Pole and Thomas Lipset*, ed. K. M. Burton (London, 1948).
- Stifel, Michael, *Arithmetica Integra* (Nuremberg, 1544).
- Stubbe, Henry, *A Light Shining out of Darkness* (London, 1659).
- Sturm, Johann Christoph, *Philosophia Eclectiva* (Altdorf, 1686).
- Suárez, Francisco, *Disputationes Metaphysicæ* (1st pub. 1597; reprint Hildesheim, 1965 [of vols. 25 and 26 of *Opera Omnia*, ed. D. M. André, Paris, 1856–78]).
- Tartaglia, Niccolò, *La Prima Parte del general trattato di Numeri e Misuri* (Venice, 1556).
- Telesio, Bernardino, *De Rerum Natvra iuxta Propria Principia Libri IX* (1st ed., 1565; Naples, 1586; facsimile reprint, Hildesheim, 1971).

Temple, William, *Admonitio de Unica P. Rami Methodo Reiectis Cæteris Retinenda* (London, 1580).

Pro Mildapetti de Unica Methodo Defensione contra Diplodophilum (London, 1581).

Toletus, Franciscus, *Commentaria una cum Questionibus in Octo Libros Aristotelis de Physica Auscultatione* (Venice, 1593).

Voltaire, François Marie Arouet de, *Lettres philosophiques*, ed. R. Naves (Paris, 1964).

Vossius, Isaac, *De Philosophia et Philosophorum Sectis* (The Hague, 1653).

Wallis, John, *A Defence of the Royal Society in Answer to the Cavails of Doctor William Holder* (London, 1678).

Ward, John, *The Lives of the Professors of Gresham College* (London, 1740).

Wecker, Jakob, *De Secretis Libri XVII* (Basel, 1582).

Weste, Richard, *The Booke of Demeanour* (London, 1619).

Whewell, William, *The Philosophy of the Inductive Sciences*, rev. ed., 2 vols. (London, 1847).

White, Thomas, *Controversy Logicke; or, The Methode to come to truth in debates of Religion* ([Paris], 1659).

Wilkins, John, *An Essay towards a Real Character, and a Philosophical Language* (London, 1668).

Worlidge, John, *Dictionarium Rusticum & Urbicunum* (London, 1704).

Zúñiga, Diego de, *In Job Commentaria* (Toledo, 1584).

Philosophia Prima Pars, Qua Perfecte et Eleganter Quatuor Scientiæ Metaphisica, Dialectica, Rhetorica, et Physica Declarantur (Toledo, 1596).

Secondary sources

Adamson, I. 'The Administration of Gresham College and Its Fluctuating Fortunes as a Scientific Institution in the Seventeenth Century', *History of Education* 9 (1980), 13–25.

Adas, Michael, *Machines as the Measure of Man: Science, Technology, and Ideologies of Western Dominance* (Ithaca, N.Y., 1989).

Albrecht, Michael, *Eklektik. Eine Begriffsgeschichte mit Hinweisen auf die Philosophie- und Wissenschaftsgeschichte* (Stuttgart/Bad Cannstatt, 1994).

Alexander, Amir, 'The Imperialist Space of Elizabethan Mathematics', *Studies in History and Philosophy of Science* 26 (1995), 559–92.

Anderson, Fulton H., *The Philosophy of Francis Bacon* (New York, 1971).

Ashworth, William B., 'Natural History and the Emblematic World View', in David C. Lindberg and Robert S. Westman, eds., *Reappraisals of the Scientific Revolution* (Cambridge, 1990), 303–32.

Baker, Herschel, *The Wars of Truth* (Gloucester, Mass., 1969).

Baldwin, T. W., *Shakespeare's Small Latine and Lesse Greeke*, 2 vols. (Urbana, 1944).

Barker, Sir Ernest, *Traditions of Civility* (Cambridge, 1948).

Baron, Hans, *The Crisis of the Early Italian Renaissance* (Princeton, 1966).

Ben-David, Joseph, *The Scientist's Role in Society: A Comparative Study* (Chicago, 1984).

Bennett, J. A., 'The Challenge of Practical Mathematics', in Stephen Pumfrey, Paolo L. Rossi, and Maurice Slawinski, eds., *Science, Culture and Popular Belief in Renaissance Europe* (Manchester, 1991), 176–90.

- Berkel, Klaas van, 'A Note on Rudolphus Snellius and the Early History of Mathematics in Leiden', in C. Hay, ed., *Mathematics from Manuscript to Print, 1300-1600* (Oxford, 1988), 156-61.
- Biagioli, Mario, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism* (Chicago, 1993).
- Binns, J. W., 'Elizabeth I and the Universities', in John Henry and Sarah Hutton, eds., *New Perspectives on Renaissance Thought* (London, 1990), 244-52.
- Blackwell, C. W. T., 'The Case of Honoré Fabri and the Historiography of Sixteenth and Seventeenth Century Jesuit Aristotelianism in Protestant History of Philosophy: Sturm, Morhof and Brucker', *Nouvelles de la Republique des Lettres* (1995), 49-77.
- 'Thales Philosophicus: The Beginning of Philosophy as a Discipline', in Donald R. Kelley, ed., *History and the Disciplines: The Reclassification of Knowledge in Early Modern Europe* (Rochester, 1997), 61-82.
- Blair, Ann, 'Humanist Methods in Natural Philosophy: The Commonplace Book', *Journal of the History of Ideas* 53 (1992), 541-51.
- The Theater of Nature: Jean Bodin and Renaissance Science* (Princeton, 1997).
- Blumenberg, Hans, *The Legitimacy of the Modern Age* (Cambridge, Mass., 1983).
- Work on Myth* (Cambridge, Mass., 1985).
- The Genesis of the Copernican World* (Cambridge, Mass., 1987).
- Boas, Marie, 'Bacon and Gilbert', *Journal of the History of Ideas* 12 (1951), 466-7.
- Brown, Harcourt, *Scientific Organizations in Seventeenth-Century France (1620-1680)* (Baltimore, 1934).
- Brown, Theodore M., 'The Rise of Baconianism in Seventeenth-Century England: A Perspective on Science and Society during the Scientific Revolution', in *Science and History: Studies in Honor of Edward Rosen*, *Studia Copernica* 16 (Wrocław, 1978), 501-22.
- Bryson, Anna, 'The Rhetoric of Status: Gesture, Demeanour and the Image of the Gentleman in Sixteenth- and Seventeenth-Century England', in Lucy Ghent and Nigel Llewellyn, eds., *Renaissance Bodies: The Human Figure in English Culture, c. 1540-1660* (London, 1990), 136-53.
- Caspari, F., *Humanism and the Social Order in Tudor England* (Chicago, 1954).
- Cavazza, Marta, 'Bologna and the Royal Society of the Seventeenth Century', *Notes and Records of the Royal Society of London* 35 (1950), 105-23.
- Chant, Colin, 'Science in Orthodox Europe', in David Goodman and Colin A. Russell, eds., *The Rise of Scientific Europe, 1500-1800* (London, 1991), 333-60.
- Charlton, William, *Aristotle's Physics I, II* (Oxford, 1970).
- Clucas, Stephen, 'In Search of "The True Logicke": Methodological Eclecticism among the "Baconian Reformers"', in Mark Greengrass, Michael Leslie, and Timothy Raylor, eds., *Samuel Hartlib and Universal Reformation* (Cambridge, 1994), 51-74.
- Clulee, Nicholas, *John Dee's Natural Philosophy* (London, 1988).
- Cohen, I. Bernard, *Franklin and Newton* (Philadelphia, 1956).
- Science and the Founding Fathers* (New York, 1995).
- Colie, Rosalie L., *Paradoxia Epidemica: The Renaissance Tradition of Paradox* (Princeton, 1966).
- Colish, Marcia L., *The Stoic Tradition from Antiquity to the Early Middle Ages, I: Stoicism in Classical Latin Literature* (Leiden, 1985).

- Copenhagen, Brian P., and Schmitt, Charles B., *Renaissance Philosophy* (Oxford, 1992).
- Craven, William G., *Giovanni della Mirandola, Symbol of His Age* (Geneva, 1981).
- Cunningham, Andrew, and Williams, Perry, 'De-centering the "Big Picture": The Origins of Modern Science and the Modern Origins of Science', *British Journal for the History of Science* 26 (1993), 407–32.
- Daston, Lorraine, 'Baconian Facts, Academic Civility, and the Prehistory of Objectivity', in Alan Megill, ed., *Rethinking Objectivity* (Durham, N.C., 1994), 37–63.
- Daston, Lorraine, and Park, Katharine, *Wonders and the Order of Nature, 1150–1750* (New York, 1998).
- Dear, Peter, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago, 1995).
- Debus, Allen G., *The English Paracelsians* (New York, 1966).
- The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries*, 2 vols. (New York, 1977).
- The French Paracelsians* (Cambridge, 1991).
- Delumeau, Jean, *La Peur en Occident (XIV^e–XVIII^e siècles): Une cité assiégée* (Paris, 1978).
- Le Péché et la Peur: La Culpabilisation en Occident, XIII^e–XVIII^e siècles* (Paris, 1983).
- 'Prescription and Reality', in Edmund Leites, ed., *Conscience and Casuistry in Early Modern Europe* (Cambridge, 1988), 134–58.
- Rassurer et protéger: Le Sentiment de sécurité dans l'Occident d'autrefois* (Paris, 1989).
- Une Histoire du Paradis: Le Jardin des délices* (Paris, 1992).
- Dillon, John, *The Middle Platonists* (London, 1977).
- Domingues, Beatriz Helena, 'Spain and the Dawn of Modern Science', *Meta-science* 7 (1998), 298–312.
- Donahue, William H., 'The Solid Planetary Spheres in Post-Copernican Natural Philosophy', in Robert S. Westman, ed., *The Copernican Achievement* (Berkeley, 1975), 244–75.
- Duhem, Pierre, *To Save the Phenomena: An Essay on the Idea of a Physical Theory from Plato to Galileo* (Chicago, 1969).
- Eamon, William, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, 1994).
- Eden, Kathy, *Poetic and Legal Fiction in the Aristotelian Tradition* (Princeton, 1986).
- Elias, Norbert, *State Formation and Civilization* (Oxford, 1982).
- The Court Society* (Oxford, 1983).
- Evans, R. J. W., *Rudolf II and His World* (Oxford, 1973).
- Farrington, Benjamin, *The Philosophy of Francis Bacon: An Essay on Its Development from 1603 to 1609 with New Translations of Fundamental Texts* (Chicago, 1964) [abbr. PFB].
- Feingold, Mordechai, *The Mathematicians' Apprenticeship: Science, Universities and Society in England, 1560–1640* (Cambridge, 1984).
- Feldhay, Rivka, *Galileo and the Church* (Cambridge, 1995).
- Findlen, Paula, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley, 1994).

- 'Francis Bacon and the Reform of Natural History in the Seventeenth Century', in Donald R. Kelley, ed., *History and the Disciplines: The Reclassification of Knowledge in Early Modern Europe* (Rochester, 1997), 239–60.
- Frank, Robert G., *Harvey and the Oxford Physiologists* (Berkeley, 1980).
- Franklin, Julian H., *Jean Bodin and the Sixteenth Century Revolution in the Methodology of Law and History* (New York, 1963).
- French, Peter J., *John Dee: The World of an Elizabethan Magus* (London, 1972).
- French, Roger, *Ancient Natural History: Histories of Nature* (London, 1994).
- William Harvey's Natural Philosophy* (Cambridge, 1994).
- Frischer, Bernard, *The Sculpted Word: Epicureanism and Philosophical Recruitment in Ancient Greece* (Berkeley, 1982).
- Gaskell, Philip, 'Books Bought by Whitgift's Pupils in the 1570s', *Transactions of the Cambridge Bibliographical Society* 7 (1979), 284–93.
- Gaukroger, Stephen, *Explanatory Structures: Concepts of Explanation in Early Physics and Philosophy* (Brighton, 1978).
- Cartesian Logic* (Oxford, 1989).
- Descartes, an Intellectual Biography* (Oxford, 1995).
- The Genealogy of Knowledge* (Aldershot, 1997).
- 'The Foundational Role of Hydrostatics and Statics in Descartes' Natural Philosophy', in Stephen Gaukroger, John Schuster, and John Sutton, eds., *Descartes' Natural Philosophy* (London, 2000), 60–80.
- Gibson, R. W., *Francis Bacon: A Bibliography of His Works and of Baconiana, to the Year 1750* (Oxford, 1950).
- Gilbert, Neal W., *Renaissance Concepts of Method* (New York, 1960).
- Goodman, David, 'Iberian Science: Navigation, Empire and Counter-Reformation', in David Goodman and Colin A. Russell, eds., *The Rise of Scientific Europe, 1500–1800* (London, 1991), 117–44.
- Grafton, Anthony, *Joseph Scaliger, a Study in the History of Classical Scholarship*, 2 vols. (Oxford, 1983–93).
- Grant, Edward, *Planets, Stars and Orbs: The Medieval Cosmos, 1200–1687* (Cambridge, 1994).
- Hacking, Ian, *The Emergence of Probability* (Cambridge, 1975).
- Hadot, Pierre, *Plotinus or the Simplicity of Vision* (Chicago, 1993).
- Philosophy as a Way of Life* (Oxford, 1995).
- Hall, A. Rupert, *Science and Society* (Aldershot, 1994).
- Hall, Thomas S., *Ideas of Life and Matter*, 2 vols. (Chicago, 1969).
- Hankins, James, *Plato in the Italian Renaissance* (Leiden, 1994).
- Hargreave, D., 'Reconstructing the Planetary Motions of the Eudoxian System', *Scripta Mathematica* 28 (1970), 335–45.
- Harkness, Deborah E., *John Dee's Conversations with Angels: Cabala, Alchemy, and the End of Nature* (Cambridge, 2000).
- Harrison, Peter, *The Bible, Protestantism, and the Rise of Natural Science* (Cambridge, 1998).
- 'The Virtues of Animals in Seventeenth-Century Thought', *Journal of the History of Ideas* 59 (1998), 463–84.
- Heltzel, Virgil B., 'Young Francis Bacon's Tutor', *Modern Language Notes* 63 (1948), 483–5.
- Hexter, J. H., *Reappraisals in History: New Views in History and Society in Early Modern Europe* (Chicago, 1979).

- Holmyard, E. J., *Alchemy* (Harmondsworth, 1957).
- Hsia, R. Po-Chia, *Social Discipline in the Reformation* (London, 1989).
- Huff, Toby, *The Rise of Early Modern Science: Islam, China, and the West* (Cambridge, 1993).
- Hunter, Michael, *The Royal Society and Its Fellows, 1660–1700: The Morphology of an Early Scientific Institution*, 2d ed. (London, 1994).
- Jacob, James R., *The Scientific Revolution* (New Jersey, 1998).
- Jacquot, Jean, 'Harriot, Hill, Warner and the New Philosophy', in John W. Shirley, ed., *Thomas Harriot: Renaissance Scientist* (Oxford, 1974), 107–28.
- Jardine, Lisa, *Francis Bacon: Discovery and the Art of Discourse* (Cambridge, 1974). *Ingenious Pursuits: Building the Scientific Revolution* (London, 1999).
- Jardine, Lisa, and Stewart, Alan, *Hostage to Fortune: The Troubled Life of Francis Bacon 1561–1626* (London, 1998).
- Jardine, Nicholas, 'Galileo's Road to Truth and the Demonstrative Regress', *Studies in History of Science* 7 (1976), 277–318.
- 'The Significance of the Celestial Orbs', *Journal of the History of Astronomy* 13 (1982), 168–94.
- 'Keeping Order in the School of Padua: Jacopo Zabarella and Francesco Piccolomini on the Offices of Philosophy', in Daniel A. Di Liscia, Eckhard Kessler, and Charlotte Methuen, eds., *Method and Order in Renaissance Philosophy of Nature: The Aristotle Commentary Tradition* (Aldershot, 1997), 183–210.
- Johns, Adrian, *The Nature of the Book* (Chicago, 1998).
- Johnson, Francis R., *Astronomical Thought in Renaissance England: A Study of English Scientific Writings from 1500 to 1645* (Baltimore, 1937).
- Jones, Richard Foster, *Ancients and Moderns: A Study of the Rise of the Scientific Movement in Seventeenth-Century England* (New York, 1982).
- Jones, Whitney R. D., *The Tudor Commonwealth, 1529–1559* (London, 1970).
- Kargon, Hugh, *Atomism in England from Harriot to Newton* (Oxford, 1966).
- Kelley, Donald R., *Foundations of Modern Historical Scholarship: Law and History in the Renaissance* (New York, 1970).
- 'History as a Calling: The Case of La Popelinière', in Anthony Molho and John A. Tedeschi, eds., *Renaissance Studies in Honour of Hans Baron* (Florence, 1971), 771–89.
- Kelly, Susanne, *The De Mundo of William Gilbert* (Amsterdam, 1965).
- Klein, Lawrence, *Shaftesbury and the Culture of Politeness* (Cambridge, 1994).
- Knowlson, James, *Universal Language Schemes in England and France, 1600–1800* (Toronto, 1975).
- Kocher, Paul H., *Science and Religion in Elizabethan England* (San Marino, Calif., 1953).
- Kuhn, Thomas S., 'Mathematical versus Experimental Traditions in the Development of Physical Science', in *The Essential Tension*, 2d ed. (Chicago, 1977), 31–65.
- Kusukawa, Sachiko, *The Transformation of Philosophy: The Case of Philip Melancthon* (Cambridge, 1995).
- Lacouture, Jean, *Jesuits, a Multibiography* (London, 1996).
- Larsen, Ann, 'Equipment for the Field', in N. Jardine, J. A. Secord, and E. C. Spary, eds., *Cultures of Natural History* (Cambridge, 1996), 358–77.
- Lattis, James M., *Between Copernicus and Galileo: Christoph Clavius and the Collapse of Ptolemaic Cosmology* (Chicago, 1994).

- Laudan, Larry, *Science and Hypothesis: Historical Essays on Scientific Methodology* (Dordrecht, 1981).
- Leary, John E., Jr., *Francis Bacon and the Politics of Science* (Ames, Iowa, 1994).
- Lemmi, Charles W., *The Classical Deities in Bacon* (Baltimore, 1933).
- Lloyd, G. E. R., *Science, Folklore and Ideology: Studies in the Life Sciences in Ancient Greece* (Cambridge, 1983).
- Adversaries and Authorities: Investigations into Ancient Greek and Chinese Science* (Cambridge, 1996).
- Loemker, Leroy E., *Struggle for Synthesis: The Seventeenth Century Background of Leibniz's Synthesis of Order and Freedom* (Cambridge, Mass., 1972).
- Lohne, Johannes A., 'Thomas Harriot als Mathematiker', *Centaurus* 11 (1965), 19–45.
- 'Dokumente zur Revalidierung von Thomas Harriot als Algebraiker', *Archive for History of Exact Sciences* 3 (1966–7), 185–205.
- Lohr, Charles, 'Jesuit Aristotelianism and Sixteenth-Century Metaphysics', in G. Fletcher and M. B. Scheute, eds., *Paradosis* (New York, 1976), 203–20.
- 'Metaphysics', in Charles B. Schmitt, Quentin Skinner, and Eckhard Kessler, eds., *The Cambridge History of Renaissance Philosophy* (Cambridge, 1988), 537–638.
- 'The Sixteenth-Century Transformation of the Aristotelian Natural Philosophy', in Eckhard Kessler, Charles H. Lohr, and Walter Sparr, *Aristotelismus und Renaissance* (Wiesbaden, 1988), 89–99.
- 'The Sixteenth-Century Transformation of the Aristotelian Division of the Speculative Sciences', in D. R. Kelley and R. H. Popkin, eds., *The Shapes of Knowledge from the Renaissance to the Enlightenment* (Dordrecht, 1991), 49–58.
- Lyons, Henry, *The Royal Society, 1660–1940* (New York, 1968).
- Maclean, Ian, *Interpretation and Meaning in the Renaissance: The Case of Law* (Cambridge, 1992).
- McRae, Robert, *The Problem of the Unity of the Sciences: Bacon to Kant* (Toronto, 1961).
- Mahoney, Micheal Sean, *The Mathematical Career of Pierre de Fermat, 1601–1665*, rev. ed. (Princeton, 1994).
- Malherbe, Michel, 'Bacon, l'Encyclopédie et la Révolution', *Études philosophiques* 3 (1985), 387–404.
- Mancosu, Paolo, *Philosophy of Mathematics and Mathematical Practice in the Seventeenth Century* (New York, 1996).
- Mandonnet, P., *Siger de Brabant et l'averroïsme latin au XIII^{me} siècle, 2^{me} partie, textes inédits*, 2d ed. (Louvain, 1908).
- Manuel, Frank E., and Manuel, Fritz P., *Utopian Thought in the Western World* (Cambridge, Mass., 1970).
- Martin, Julian, *Francis Bacon, the State, and the Reform of Natural Philosophy* (Cambridge, 1992).
- Marwil, Jonathan, *The Trials of Counsel: Francis Bacon in 1621* (Detroit, 1976).
- Mayer, Thomas F., *Thomas Starkey and the Commonweal* (Cambridge, 1989).
- Mikkeli, Heikki, 'The Foundation of an Autonomous Natural Philosophy: Zabarrella on the Classification of Arts and Sciences', in Daniel A. Di Liscia, Eckhard Kessler, and Charlotte Methuen, eds., *Method and Order in Renaissance Philosophy of Nature: The Aristotle Commentary Tradition* (Aldershot, 1997), 211–28.

- Milner, Benjamin, 'Francis Bacon: The Theological Foundations of *Valerius Terminus*', *Journal for the History of Ideas* 58 (1997), 245–64.
- Moss, Ann, *Printed Commonplace-Books and the Structuring of Renaissance Thought* (Oxford, 1996).
- 'The *Politica* of Justus Lipsius and the Commonplace-Book', *Journal of the History of Ideas* 59 (1998), 421–36.
- Mulsow, Martin, *Frühneuzeitliche Selbsterhaltung: Telesio und die Naturphilosophie der Renaissance* (Tübingen, 1998).
- Navarro Brotóns, Víctor, 'The Reception of Copernicus in Sixteenth-Century Spain: The Case of Diego de Zúñiga', *Isis* 86 (1995), 52–78.
- Newman, William R., *Gehennical Fire: The Lives of George Starkey, an American Alchemist in the Scientific Revolution* (Cambridge, Mass., 1994).
- Oestreicht, Gerhardt, *Neostoicism and the Early Modern State* (Cambridge, 1982).
- Ong, Walter J., *Ramus, Method and the Decay of Dialogue* (Cambridge, Mass., 1983).
- Pagel, Walter, *Paracelsus: An Introduction to Philosophical Medicine in the Era of the Renaissance* (Basel, 1958).
- Park, Katharine, and Kessler, Eckhard, 'The Concept of Psychology', in Charles B. Schmitt, Quentin Skinner, and Eckhard Kessler, eds., *The Cambridge History of Renaissance Philosophy* (Cambridge, 1988), 455–63.
- Pepper, Jon V., 'Harriot's Calculation of the Meridional Parts as Logarithmic Tangents', *Archive for History of Exact Sciences* 4 (1968), 359–413.
- 'Harriot's Earlier Work on Mathematical Navigation: Theory and Practice', John W. Shirley, ed., *Thomas Harriot: Renaissance Scientist* (Oxford, 1974), 54–90.
- Pérez-Ramos, Antonio, *Francis Bacon's Idea of Science and the Maker's Knowledge Tradition* (Oxford, 1988).
- Pine, Martin L., *Pietro Pomponazzi: Radical Philosopher of the Renaissance* (Padua, 1986).
- Pirotti, Umberto, 'Aristotelian Philosophy and the Popularisation of Learning: Benedetto Varchi and Renaissance Aristotelianism', in Eric Cochrane, ed., *The Late Italian Renaissance 1525–1630* (New York, 1970), 168–208.
- Pocock, J. G. A., *The Machiavellian Moment: Florentine Political Thought and the Atlantic Republican Tradition* (Princeton, 1975).
- Principe, Lawrence M., *The Aspiring Adept: Robert Boyle and His Alchemical Quest* (Princeton, 1998).
- Pumfrey, Stephen, 'William Gilbert's Magnetic Philosophy, 1580–1684: The Creation and Dissolution of a Discipline', Ph.D. thesis (Warburg Institute, London, 1987).
- 'The History of Science and the Renaissance Science of History', in Stephen Pumfrey, Paolo L. Rossi, and Maurice Slawinski, eds., *Science, Culture and Popular Belief in Renaissance Europe* (Manchester, 1991), 48–70.
- Pyle, Andrew, *Atomism and Its Critics* (Bristol, 1995).
- Rabbow, Paul, *Seelenführung: Methodik der Exerzitien in der Antike* (Munich, 1954).
- Ramati, Ayval, 'Harmony at a Distance: Leibniz's Scientific Academies', *Isis* 87 (1996), 430–52.
- Randall, John H., *The School of Padua and the Emergence of Modern Science* (Padua, 1961).

- Ranea, Alberto Guillermo, 'A "Science for *honnêtes hommes*": *La Recherche de la Vérité* and the Deconstruction of Experimental Knowledge', in Stephen Gaukroger, John Schuster, and John Sutton, eds., *Descartes' Natural Philosophy* (London, 2000), 313–29.
- Rankin, H. D., *Sophists, Socratics and Cynics* (London, 1983).
- Redondi, Pietro, *Galileo Heretic* (Princeton, 1989).
- Rees, Graham, 'Francis Bacon's Semi-Paracelsian Cosmology', *Ambix* 22 (1975), 81–101.
- 'Francis Bacon's Semi-Paracelsian Cosmology and the *Great Instauration*', *Ambix* 22 (1975), 161–73.
- 'Matter Theory: A Unifying Factor in Bacon's Natural Philosophy?', *Ambix* 24 (1977), 110–25.
- 'Francis Bacon on Verticity and the Bowels of the Earth', *Ambix* 26 (1979), 202–11.
- 'Atomism and "Subtlety" in Francis Bacon's Philosophy', *Annals of Science* 37 (1980), 549–71.
- 'An Unpublished Manuscript by Francis Bacon: *Sylva Sylvarum* Drafts and Other Working Notes', *Annals of Science* 38 (1981), 377–412.
- 'Bacon's Philosophy: Some New Sources with Special Reference to the *Abece-darium Novum Naturæ*', in Marta Fattori, ed., *Francis Bacon: terminologia e fortuna nel XVII secolo* (Rome, 1984), 223–44.
- 'Francis Bacon and Spiritus Vitalis', in M. Fattori and M. Bianchi, eds., *Spiritus: IV^o Colloquio Internazionale del Lessico Intellettuale Europeo* (Rome, 1984), 265–81.
- Reiss, Timothy, *The Discourse of Modernism* (Ithaca, 1982).
- Knowledge, Discovery and Imagination in Early Modern Europe* (Cambridge, 1997).
- Rosen, Stanley, *The Quarrel between Philosophy and Poetry* (New York, 1993).
- Rossi, Paolo, *Francis Bacon: From Magic to Science* (Chicago, 1968).
- Santinello, Giovanni, with Francesco Bottin, Luciano Malusa, Giuseppe Micheli, and Ilario Tolomio, *Models of the History of Philosophy: I, From Its Origins in the Renaissance to the 'Historia Philosophica'*, gen. ed. (for English edition) C. W. T. Blackwell (Dordrecht, 1993).
- Schmitt, Charles B., *Aristotle and the Renaissance* (Cambridge, Mass., 1983).
- Schneider, Ulrich Johannes, 'Eclecticism and the History of Philosophy', in Donald R. Kelley, ed., *History and the Disciplines: The Reclassification of Knowledge in Early Modern Europe* (Rochester, 1997), 83–102.
- Schofield, Christine, 'The Tychonic and Semi-Tychonic World Systems', in René Taton and Curtis Wilson, eds., *Planetary Astronomy from the Renaissance to the Rise of Astrophysics, Part A: Tycho Brahe to Newton* (Cambridge, 1989), 33–44.
- Sepper, Dennis, 'The Texture of Thought: Why Descartes' *Meditationes* Is Meditational and Why It Matters', in Stephen Gaukroger, John Schuster, and John Sutton, eds., *Descartes' Natural Philosophy* (London, 2000), 736–50.
- Seznec, Jean, *The Survival of Pagan Gods* (Princeton, 1973).
- Shackelford, Jole, 'Tycho Brahe, Laboratory Design, and the Aim of Science', *Isis* 84 (1993), 211–30.
- Shapin, Steven, *A Social History of Truth: Civility and Science in Seventeenth Century England* (Chicago, 1994).

- Shapin, Steven, and Schaffer, Simon, *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, 1985).
- Shenton, W. R., 'The First English Euclid', *American Mathematical Monthly* 25 (1928), 505–11.
- Sherman, William H., *John Dee: The Politics of Reading and Writing in the English Renaissance* (Amherst, 1995).
- Skinner, Quentin, *The Foundations of Modern Political Thought*, 2 vols. (Cambridge, 1978).
- Reason and Rhetoric in the Philosophy of Hobbes* (Cambridge, 1996).
- Slaughter, M. M., *Universal Language and Scientific Taxonomy in the Seventeenth Century* (Cambridge, 1982).
- Smith, Pamela H., *The Business of Alchemy: Science and Culture in the Holy Roman Empire* (Princeton, 1994).
- Sorabji, Richard, *Necessity, Cause and Blame* (London, 1980).
- Stewart, Larry, *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660–1750* (Cambridge, 1992).
- Swordlow, Noel M., 'The Derivation and First Draft of Copernicus' Planetary Theory: A Translation of the *Commentariolus* with Commentary', *Proceedings of the American Philosophical Society* 117 (1973), 423–512.
- 'Pseudodoxia Copernicana; or, Enquiries into Very Many Received Tenets and Commonly Presumed Truths, Mostly Concerning Spheres', *Archives internationales d'histoire des sciences* 26 (1976), 108–58.
- Taylor, E. G. R., *The Mathematical Practitioners of Tudor and Stuart England* (Cambridge, 1954).
- Thoren, Victor E., with contributions by John R. Christianson, *The Lord of Uraniborg: A Biography of Tycho Brahe* (Cambridge, 1990).
- Thorndike, Lynn, *A History of Magic and Experimental Science*, 8 vols. (New York, 1923–58).
- Trinkaus, Charles, *In Our Image and Likeness: Humanity and Divinity in Italian Humanist Thought*, 2 vols. (London, 1970).
- Vickers, Brian, 'Rhetoric and Poetics', in Charles B. Schmitt, Quentin Skinner, and Eckhard Kessler, eds., *The Cambridge History of Renaissance Philosophy* (Cambridge, 1988), 715–45.
- 'Bacon and Rhetoric', in Markku Peltonen, ed., *The Cambridge Companion to Bacon* (Cambridge, 1996), 200–31.
- Walker, D. P., 'Francis Bacon and Spiritus', in D. P. Walker, *Music, Spirit and Language in the Renaissance*, ed. Penelope Gouk (London, 1985), 121–30.
- Waters, D. W., *The Art of Navigation in England in Elizabethan and Early Stuart Times* (Greenwich, 1978).
- Webster, Charles, *The Great Instauration: Science, Medicine and Reform (1626–1660)* (London, 1975).
- Weeks, Andrew, *Paracelsus: Speculative Theory and the Crisis of the Early Reformation* (Albany, 1997).
- Westfall, Richard S., *Science and Religion in Seventeenth-Century England* (Ann Arbor, 1973).
- Westman, Robert S., 'The Melancthon Circle, Reticus, and the Wittenberg Interpretation of the Copernican Theory', *Isis* 66 (1975), 165–93.
- 'The Astronomer's Role in the Sixteenth Century: A Preliminary Study', *History of Science* 18 (1980), 105–47.

- Wieland, Georg, 'The Reception and Interpretation of Aristotle's *Ethics*', in Norman Kretzmann, Anthony Kenny, and Jan Pinborg, eds., *The Cambridge History of Later Medieval Philosophy* (Cambridge, 1982), 657–72.
- Wilson, Catherine, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton, 1995).
- Wood, Paul B., 'The Science of Man', in N. Jardine, J. A. Secord, and E. C. Spary, eds., *Cultures of Natural History* (Cambridge, 1996), 197–210.
- Worden, Blair, *The Sound of Virtue* (New Haven, 1996).
- Wrightman, W. P. D., *Science and the Renaissance*, 2 vols. (Edinburgh, 1962).
- Yates, Frances, *Giordano Bruno and the Hermetic Tradition* (Chicago, 1964).
- The Occult Philosophy in the Elizabethan Age* (London, 1979).
- Yeo, Richard, 'Ephraim Chamber's *Cyclopedia* (1728) and the Tradition of Commonplaces', *Journal of the History of Ideas* 57 (1996), 157–75.
- Yuan Weishi, 'A Few Problems Related to Nineteenth Century Chinese and Western Philosophies and Their Cultural Interaction', *Journal of Chinese Philosophy* 22 (1995), 153–92.
- Zagorin, Perez, *Francis Bacon* (Princeton, 1998).

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